PROCEEDINGS

OF

THE AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE,

THIRTIETH MEETING,

HELD AT

CINCINNATI, OHIO,

AUGUST, 1881.

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FREDERICK W. PUTNAM,
Permanent Secretary.

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MEETING.	DATE.	PLACE.	CHAIRMAN.	SECRETARY.	ASSIST. SEC'Y.	TREASURER.
1st	April 2, 1840,	Philadelphia,	Edward Hitchcock,*	L. C. Beck,*		
2d	April 5, 1841,	Philadelphia,	Benjamin Silliman,*	L. C. Beck,*	B. Silliman, jr., C. B. Trego,	
3d	April 25, 1842,	Boston,	S. G. Morton,*	C. T. Jackson,*	J. D. Whitney, M. B. Williams,	
4th	April 26, 1843,	Albany,	Henry D. Rogers,*	B. Silliman, jr.,		John Locke.*
5th	May 8, 1844,	Washington,	John Locke,*	B. Silliman, jr., O. P. Hubbard,		Douglas Houghton.*
6th	April 30, 1845,	New Haven,	Wm. B. Rogers,	B. Silliman, jr., J. Lawrence Smith,		Douglas Houghton.*
7th	Sept. 2, 1846,	New York,	C. T. Jackson,*	B. Silliman, jr.,		E. C. Herrick.*
8th	Sept. 20, 1847,	Boston,	Wm. B. Rogers,†	Jeffries Wyman,*		B. Silliman, jr.

* Deceased.

†Professor ROGERS, as chairman of this last meeting, called the first meeting of the new Association to order and presided until it was fully organized by the adoption of a constitution. As he was thus the first presiding officer of the new Association, it was directed at the Hartford meeting that his name be placed at the head of the Past Presidents of the American Association for the Advancement of Science.

MEETINGS AND OFFICERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE-PRESIDENT.	GENERAL SECRETARY.	PERMANENT SEC'Y.	TREASURER.
1st	Sept. 20, 1848,	Philadelphia, Pa.,	W. C. Redfield.*		Walter R. Johnson,*		Jeffries Wyman.*
2d	Aug. 14, 1849,	Cambridge, Mass.,	Joseph Henry,*		E. N. Horsford, 1		A. L. Elwyn.
3d	Mar. 12, 1850,	Charleston, S. C.,	A. D. Bache,* 2		L. R. Gibbs, 3		St. J. Ravenel.* 4
4th	Aug. 19, 1850,	New Haven, Conn.,	A. D. Bache,*		E. C. Herrick,*		A. L. Elwyn.
5th	May 5, 1851,	Cincinnati, Ohio,	A. D. Bache,*		W. B. Rogers, 5	S. F. Baird,	S. F. Baird. 6
6th	Aug. 19, 1851,	Albany, N. Y.,	Louis Agassiz,*		W. B. Rogers,	S. F. Baird,	A. L. Elwyn.
7th	July 28, 1853,	Cleveland, Ohio,	Benjamin Pierce,*		S. St. John, 7	S. F. Baird,	A. L. Elwyn.
8th	April 26 1854,	Washington, D.C.,	J. D. Dana,		J. Lawrence Smith,	Joseph Lovering,	J. L. LeConte. 8
9th	Aug. 15, 1855,	Providence, R. I.,	John Torrey,*		Wolcott Gibbs,	Joseph Lovering,	A. L. Elwyn.
10th	Aug. 20, 1856,	Albany, N. Y.,	James Hall,		B. A. Gould,	Joseph Lovering,	A. L. Elwyn.
11th	Aug. 12, 1857,	Montreal, Canada,	Alexis Caswell,* 9	Alexis Caswell,*	John LeConte,	Joseph Lovering,	A. L. Elwyn.
12th	April 28, 1858,	Baltimore, Md.,	Alexis Caswell,* 10	John E. Holbrook,*†	W. M. Gillespie,* 11	Joseph Lovering,	A. L. Elwyn.
13th	Aug. 3, 1859,	Springfield, Mass.,	Stephen Alexander,	Edward Hitchcock,*	William Chauvenet,*	Joseph Lovering,	A. L. Elwyn.
14th	Aug. 1, 1860,	Newport, R. I.,	Isaac Lea,	B. A. Gould,	Joseph LeConte,	Joseph Lovering,	A. L. Elwyn.
15th	Aug. 15, 1866,	Buffalo, N. Y.,	F. A. P. Barnard,	A. A. Gould,* 12	Elias Loomis, 13	Joseph Lovering,	A. L. Elwyn.†
16th	Aug. 21, 1867,	Burlington, Vt.,	J. S. Newberry,	Wolcott Gibbs,	C. S. Lyman,	Joseph Lovering,	A. L. Elwyn.†
17th	Aug. 5, 1868,	Chicago, Ill.,	B. A. Gould,	Charles Whittlesey,	Simon Newcomb, 14	Joseph Lovering,	A. L. Elwyn.†
18th	Aug. 18, 1869,	Salem, Mass.,	J. W. Foster,*	O. N. Rood,	O. C. Marsh,	F. W. Putnam, 15	A. L. Elwyn.†
19th	Aug. 17, 1870,	Troy, N. Y.,	T. S. Hunt, 16	T. S. Hunt,	F. W. Putnam, 17	Joseph Lovering,	A. L. Elwyn.†
20th	Aug. 16, 1871,	Indianapolis, Ind.,	Asa Gray,	G. F. Barker,	F. W. Putnam,	Joseph Lovering,	W. S. Vaux.
21st	Aug. 15, 1872,	Dubuque, Iowa,	J. Lawrence Smith,	Alex. Winchell,	E. S. Morse,	Joseph Lovering,	W. S. Vaux.
22d	Aug. 20, 1873,	Portland, Me.,	Joseph Lovering,	A. H. Worthen,†	C. A. White,	F. W. Putnam,	W. S. Vaux.
23d	Aug. 12, 1874,	Hartford, Conn.,	J. L. LeConte,	C. S. Lyman,	A. C. Hamlin,	F. W. Putnam,	W. S. Vaux.†

1. In place of Jeffries Wyman, *not present.*
2. In place of Joseph Henry, *not present.*
3. In place of E. C. Herrick, *not present.*
4. In place of A. L. Elwyn, *not present.*
5. In place of E. C. Herrick, *not present.*
6. In place of A. L. Elwyn, *not present.*
7. In place of J. D. Dana, *not present.*
8. In place of A. L. Elwyn, *not present.*
9. In place of J. W. Bailey, *deceased.*
10. In place of Jeffries Wyman, *not present.*
11. In place of Wm. Chauvenet, *not present.*
12. In place of R. W. Gibbes, *not present.*
13. In place of W. P. Trowbridge, *not present.*
14. In place of A. P. Rockwell, *called home 1st day.*
15. In place of Joseph Lovering, *in Europe.*
16. In place of Wm. Chauvenet, *too ill to be present.*
17. In place of C. F. Hartt, *in Brazil.*

* Deceased. † Not present at the meeting.

MEETINGS AND OFFICERS OF THE ASSOCIATION (*Continued*).

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENT, SECTION A.	VICE PRESIDENT, SECTION B.	CHAIRMAN OF PERMANENT SUBSECTION OF CHEMISTRY.	CHAIRMAN OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	CHAIRMAN OF PERMANENT SUBSECTION OF MICROSCOPY.	CHAIRMAN OF PERMANENT SUBSECTION OF ENTOMOLOGY.
24th	Aug. 11, 1875.	Detroit, Mich.,	J. E. Hilgard,	H. A. Newton,	J. W. Dawson,	S. W. Johnson,	L. H. Morgan,*	————	————
25th	Aug. 23, 1876.	Buffalo, N. Y.,	W. B. Rogers,	C. A. Young,	E. S. Morse,	G. F. Barker,	L. H. Morgan,*	R. H. Ward,	————
26th	Aug. 29, 1877.	Nashville, Tenn.,	S. Newcomb,	R. H. Thurston,[1]	O. C. Marsh,	N. T. Lupton,	Daniel Wilson,†	R. H. Ward,	————
27th	Aug. 21, 1878.	St. Louis, Mo.,	O. C. Marsh,	R. H. Thurston,	Aug. R. Grote,	F. W. Clarke,	————[2]	R. H. Ward,[3]	————
28th	Aug. 27, 1879.	Saratoga, N. Y.,	G. F. Barker,	S. P. Langley,	J. W. Powell,	F. W. Clarke,[4]	Daniel Wilson,	E. W. Morley,	————
29th	Aug. 25, 1880.	Boston, Mass.,	L. H. Morgan,*	Asaph Hall,	Alex. Agassiz,	J. M. Ordway,	J. W. Powell,	S. A. Lattimore,	————
30th	Aug. 17, 1881.	Cincinnati, Ohio,	G. J. Brush,	Wm. Harkness,[7]	E. T. Cox,[8]	G. C. Caldwell,[9]	G. Mallery,	A. B. Hervey,	J. G. Morris.

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF SECTION A.	SECRETARY OF SECTION B.	SECRETARY OF PERMANENT SUBSECTION OF CHEMISTRY.	SECRETARY OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	SECRETARY OF PERMANENT SUBSECTION OF MICROSCOPY.	SECRETARY OF PERMANENT SUBSECTION OF ENTOMOLOGY.	TREASURER.
F. W. Putnam,	S. H. Scudder,	{ S. P. Langley, T. C. Mendenhall,	E. S. Morse,	F. W. Clarke,	F. W. Putnam,	————	————	W. S. Vaux.
F. W. Putnam,	T. C. Mendenhall,	A. W. Wright,	Albert H. Tuttle,	H. C. Bolton,	O. T. Mason,	E. W. Morley,	————	W. S. Vaux.
F. W. Putnam,	Aug. R. Grote,	H. C. Bolton,	Wm. H. Dall,	P. Schweitzer,	————[2]	T. O. Summers, jr.,	————	W. S. Vaux.†
F. W. Putnam,	H. C. Bolton,	F. E. Nipher,	George Little,	A. P. S. Stuart,	————[2]	G. J. Engelmann,	————	W. S. Vaux.†
F. W. Putnam,	H. C. Bolton,[5]	J. K. Rees,	W. H. Dall,[6]	W. R. Nichols,	J. G. Henderson,	A. B. Hervey,	————	W. S. Vaux.†
F. W. Putnam,	J. K. Rees,	H. B. Mason,	C. V. Riley,	C. E. Munroe,	J. G. Henderson,	A. B. Hervey,	————	W. S. Vaux
F. W. Putnam,	C. V. Riley,	E. T. Tappan,[10]	Wm. Saunders,	A. Springer,[12]	J. G. Henderson,	W. H. Seaman,[11]	B. P. Mann,	W. S. Vaux.†

[1] In the absence of E. C. Pickering.
[2] The Subsection united with Sec. B.
[3] In the absence of G. S. Blackie.
[4] In the absence of Ira Remsen.
[5] In the absence of George Little.
[6] In the absence of A. C. Wetherby.
[7] In the absence of A. M. Mayer.
[8] In the absence of George Engelmann.
[9] In the absence of W. R. Nichols.
[10] In the absence of John Trowbridge.
[11] In the absence of S. P. Sharples.
[12] In place of H. W. Wiley, called away.
* Deceased.
† Not present.

COMMONWEALTH OF MASSACHUSETTS.

IN THE YEAR ONE THOUSAND EIGHT HUNDRED AND SEVENTY-FOUR.

AN ACT

TO INCORPORATE THE "AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE."

Be it enacted by the Senate and House of Representatives, in General Court assembled, and by the authority of the same, as follows:

SECTION 1. Joseph Henry of Washington, Benjamin Pierce of Cambridge, James D. Dana of New Haven, James Hall of Albany, Alexis Caswell of Providence, Stephen Alexander of Princeton, Isaac Lea of Philadelphia, F. A. P. Barnard of New York, John S. Newberry of Cleveland, B. A. Gould of Cambridge, T. Sterry Hunt of Boston, Asa Gray of Cambridge, J. Lawrence Smith of Louisville, Joseph Lovering of Cambridge and John LeConte of Philadelphia, their associates, the officers and members of the Association, known as the "American Association for the Advancement of Science," and their successors, are hereby made a corporation by the name of the "American Association for the Advancement of Science," for the purpose of receiving, purchasing, holding and conveying real and personal property, which it now is, or hereafter may be possessed of, with all the powers and privileges, and subject to the restrictions, duties and liabilities set forth in the general laws which now or hereafter may be in force and applicable to such corporations.

SECTION 2. Said corporation may have and hold by purchase, grant, gift or otherwise, real estate not exceeding one hundred thousand dollars in value, and personal estate of the value of two hundred and fifty thousand dollars.

SECTION 3. Any two of the corporators above named are hereby authorized to call the first meeting of the said corporation in the month of August next ensuing, by notice thereof "by mail," to each member of the said Association.

SECTION 4. This act shall take effect upon its passage.

HOUSE OF REPRESENTATIVES, March 10, 1874.
Passed to be enacted,
JOHN E. SANFORD, *Speaker*

IN SENATE, March 17, 1874.
Passed to be enacted,
GEO. B. LORING, *President.*

March 19, 1874.
Approved,
W. B. WASHBURN

SECRETARY'S DEPARTMENT,
Boston, April 3, 1874.
A true copy, Attest:
DAVID PULSIFER,
Deputy Secretary of the Commonwealth.

CONSTITUTION

OF THE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.*

Incorporated by Act of the General Court of the Commonwealth of Massachusetts.

OBJECTS.

ARTICLE 1. The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness.

MEMBERS, FELLOWS, PATRONS AND HONORARY FELLOWS.

ART. 2. The Association shall consist of Members, Fellows, Patrons, and Honorary Fellows.

ART. 3. Any person may become a Member of the Association upon recommendation in writing by two members or fellows, nomination by the Standing Committee, and election by a majority of the members and fellows present in General Session.

ART. 4. Fellows shall be nominated by the Standing Committee from such of the members as are professionally engaged in science, or have by their labors aided in advancing science. The election of fellows shall be by ballot and a majority vote of the members and fellows present in General Session.†

ART. 5. Any person paying to the Association the sum of one thousand dollars shall be classed as a Patron, and shall be entitled to all the privileges of a member and to all its publications.

ART. 6. Honorary Fellows of the Association, not exceeding three for each section, may be elected; the nominations to be made by the Stand-

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*As amended at the Cincinnati Meeting, August, 1881, and to take effect at the Montreal Meeting, August, 1882.

†When this article was adopted in 1874 the following clause was added, but was stricken out as inoperative when the constitution was amended in 1881: —

"But all persons who may be members at the time of the adoption of this constitution may become fellows by signifying their desire to this effect before the first day of August, 1875."

ing Committee and approved by ballot in the respective sections before election by ballot in General Session. Honorary Fellows shall be entitled to all the privileges of fellows and shall be exempt from all fees and assessments, and entitled to all publications of the Association issued after the date of their election.

ART. 7. The name of any member or fellow two years in arrears for annual dues shall be erased from the list of the Association, provided that two notices of indebtedness, at an interval of at least three months, shall have been given; and no such person shall be restored until he has paid his arrearages or has been reëlected.

ART. 8. No member or fellow shall take part in the organization of, or hold office in, more than one section at any one meeting.

OFFICERS.

ART. 9. The Officers of the Association shall be elected by ballot in General Session from the fellows, and shall consist of a President, a Vice President from each section, a Permanent Secretary, a General Secretary, an Assistant General Secretary, a Treasurer, and a Secretary of each Section; these, with the exception of the Permanent Secretary, shall be elected at each meeting for the following one, and, with the exception of the Treasurer and the Permanent Secretary, shall not be reëligible for the next two meetings. The term of office of Permanent Secretary shall be five years.

ART. 10. The President, or, in his absence, the senior Vice President present, shall preside at all General Sessions of the Association and at all meetings of the Standing Committee. It shall also be the duty of the President to give an address at a General Session of the Association at the meeting following that over which he presided.

ART. 11. The Vice Presidents shall be the chairmen of their respective Sections, and of their Sectional Committees, and it shall be part of their duty to give an address, each before his own section, at such time as the Standing Committee shall determine. The Vice Presidents may appoint temporary chairmen to preside over the sessions of their sections, but shall not delegate their other duties. The Vice Presidents shall have seniority in order of their continuous membership in the Association.

ART. 12. The General Secretary shall be the Secretary of all General Sessions of the Association, and shall keep a record of the business of these sessions. He shall receive the records from the Secretaries of the

Sections, which, after examination, he shall transmit with his own records to the Permanent Secretary within two weeks after the adjournment of the meeting. He shall receive proposals for membership and bring them before the Standing Committee.

ART. 13. The Assistant General Secretary shall be the Secretary of the Standing Committee. He shall give to the Secretary of each Section the titles of papers assigned to it by the Standing Committee.

ART. 14. The Permanent Secretary shall be the executive officer of the Association under the direction of the Standing Committee. He shall attend to all business not specially referred to committees nor otherwise constitutionally provided for. He shall keep an account of all business that he has transacted for the Association, and make annually a general report for publication in the annual volume of Proceedings. He shall attend to the printing and distribution of the annual volume of Proceedings, and all other printing ordered by the Association. He shall issue a circular of information to members and fellows at least three months before each meeting, and shall, in connection with the Local Committee, make all necessary arrangements for the meetings of the Association. He shall provide the Secretaries of the Association with such books and stationery as may be required for their records and business, and shall provide members and fellows with such blank forms as may be required for facilitating the business of the Association. He shall collect all assessments and admission fees, and notify members and fellows of their election, and of any arrearages. He shall receive, and bring before the Standing Committee, the titles and abstracts of papers proposed to be read before the Association. He shall keep an account of all receipts and expenditures of the Association, and report the same annually at the first meeting of the Standing Committee, and shall pay over to the Treasurer such unexpended funds as the Standing Committee may direct. He shall receive and hold in trust for the Association all books, pamphlets and manuscripts belonging to the Association, and allow the use of the same under the provisions of the Constitution and the orders of the Standing Committee. He shall receive all communications addressed to the Association during the interval between meetings, and properly attend to the same. He shall at each meeting report the names of fellows and members who have died since the preceding meeting. He shall be allowed a salary which shall be determined by the Standing Committee, and may employ one or more clerks at such compensation as may be agreed upon by the Standing Committee.

ART. 15. The Treasurer shall invest the funds received by him in such securities as may be directed by the Standing Committee. He shall annually present to the Standing Committee an account of the funds in his charge. No expenditure of the principal in the hands of the Treasurer shall be made without a unanimous vote of the Standing Committee, and no expenditure of the income received by the Treasurer shall be made without a two-thirds vote of the Standing Committee.

ART. 16. The Secretaries of the Sections shall keep the records of their respective sections, and, at the close of the meeting, give the same, including the records of subsections, to the General Secretary. They shall also be the Secretaries of the Sectional Committees. The Secretaries shall have seniority in order of their continuous membership in the Association.

ART. 17. In case of a vacancy in the office of the President, one of the Vice Presidents shall be elected by the Standing Committee as the President of the meeting. Vacancies in the offices of Vice President, Permanent Secretary, General Secretary, Assistant General Secretary, and Treasurer, shall be filled by nomination of the Standing Committee and election by ballot in General Session. A vacancy in the office of Secretary of a Section shall be filled by nomination and election by ballot in the Section.

ART. 18. The Standing Committee shall consist of the past Presidents, and the Vice Presidents of the last meeting, together with the President, the Vice Presidents, the Permanent Secretary, the General Secretary, the Assistant General Secretary, the Secretaries of the Sections, and the Treasurer of the current meeting, with the addition of one fellow elected from each Section by ballot on the first day of its meeting. The members present at any regularly called meeting of the Committee, provided there are at least five, shall form a quorum for the transaction of business. The Standing Committee shall meet on the day preceding each annual meeting of the Association, and arrange the programme for the first day of the sessions. The time and place of this first meeting shall be designated by the Permanent Secretary. Unless otherwise agreed upon, regular meetings of the Committee shall be held in the committee room at 9 o'clock, A. M., on each day of the meeting of the Association. Special meetings of the Committee may be called at any time by the President. The Standing Committee shall be the board of supervision of the Association, and no business shall be transacted by the Association that has not first been referred to, or originated with, the Committee. The Committee shall receive and assign papers to the respective sections; examine and, if necessary, exclude papers; decide which papers, discussions and other

proceedings shall be published, and have the general direction of the publications of the Association; manage the financial affairs of the Association; arrange the business and programmes for General Sessions; suggest subjects for discussion, investigation or reports; nominate members and fellows; and receive and act upon all invitations extended to the Association and report the same at a General Session of the Association.

ART. 19. The Nominating Committee shall consist of the Standing Committee, and one member or fellow elected by each of the Sections. It shall be the duty of this Committee to meet at the call of the President and nominate the general officers for the following meeting of the Association. It shall also be the duty of this Committee to recommend the time and place for the next meeting. The Vice President and Secretary of each Section shall be recommended to the Nominating Committee by a sub-committee consisting of the Vice President, Secretary, and three members or fellows elected by the Section.

MEETINGS.

ART. 20. The Association shall hold a public meeting annually, for one week or longer, at such time and place as may be determined by vote of the Association, and the preliminary arrangements for each meeting shall be made by the Local Committee, in conjunction with the Permanent Secretary and such other persons as the Standing Committee may designate.

ART. 21. General Sessions shall be held at 10 o'clock, A. M., unless otherwise ordered, on every day of the meeting, Sunday excepted, and at such other times as may be appointed by the Standing Committee.

SECTIONS AND SUBSECTIONS.

ART. 22. The Association shall be divided into nine Sections, namely :— A, *Mathematics and Astronomy;* B, *Physics;* C, *Chemistry, including its application to agriculture and the arts;* D, *Mechanical Science;* E, *Geology and Geography;* F, *Biology;* G, *Histology and Microscopy;* H, *Anthropology;* I, *Economic Science and Statistics.* The Standing Committee shall have power to consolidate any two or more Sections temporarily, and such consolidated Sections shall be presided over by the senior Vice President and Secretary of the Sections comprising it.

ART. 23. Immediately on the organization of a Section there shall be three fellows elected by ballot after open nomination, who, with the Vice President and Secretary, shall form its Sectional Committee. The Sectional Committees shall have power to fill vacancies in their own numbers. Meetings of the Sections shall not be held at the same time with a General Session.

ART. 24. The Sectional Committee of any Section may at its pleasure form one or more temporary Subsections, and may designate the officers thereof. The Secretary of a Subsection shall, at the close of the meeting, transmit his records to the Secretary of the Section.

ART. 25. A paper shall not be read in any Section nor Subsection until it has been received from the Standing Committee and placed on the programme of the day by the Sectional Committee.

SECTIONAL COMMITTEES.

ART. 26. The Sectional Committees shall arrange and direct the business of their respective Sections. They shall prepare the daily programmes and give them to the Permanent Secretary for printing at the earliest moment practicable. No titles of papers shall be entered on the daily programmes except such as have passed the Standing Committee. No change shall be made in the programme for the day in a Section without the consent of the Sectional Committee. The Sectional Committees may refuse to place the title of any paper on the programme; but every such title, with the abstract of the paper or the paper itself, must be returned to the Standing Committee with the reasons why it was refused.

ART. 27. The Sectional Committees shall examine all papers and abstracts referred to the sections, and they shall not place on the programme any paper inconsistent with the character of the Association; and to this end they have power to call for any paper, the character of which may not be sufficiently understood from the abstract submitted.

PAPERS AND COMMUNICATIONS.

ART. 28. All members and fellows must forward to the Permanent Secretary, as early as possible, and when practicable before the convening of the Association, full titles of all the papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery, and also such abstracts of their contents as will give a general idea of their nature; and no title shall be referred by the Standing Committee to the Sectional Committee until an abstract of the paper or the paper itself has been received.

ART. 29. If the author of any paper be not ready at the time assigned, the title may be dropped to the bottom of the list.

ART. 30. Whenever practicable, the proceedings and discussions at General Sessions, Sections and Subsections shall be reported by professional reporters, but such reports shall not appear in print as the official reports of the Association unless revised by the Secretaries.

PRINTED PROCEEDINGS.

ART. 31. The Permanent Secretary shall have the Proceedings of each meeting printed in an octavo volume as soon after the meeting as possible, beginning one month after adjournment. Authors must prepare their papers or abstracts ready for the press and forward them to the Permanent Secretary within this interval, otherwise only the abstracts or titles taken from the "title blanks" will appear in the printed volume. The Standing Committee shall have power to order the printing of any paper by abstract or title only. Whenever practicable, proofs shall be forwarded to authors for revision. If any additions or substantial alterations are made by the author of a paper after its submission to the Secretary, the same shall be distinctly indicated. Illustrations must be provided for by the authors of the papers, or by a special appropriation from the Standing Committee. Immediately on publication of the volume, a copy shall be forwarded to every member and fellow of the Association who shall have paid the assessment for the meeting to which it relates, and it shall also be offered for sale by the Permanent Secretary at such price as may be determined by the Standing Committee. The Standing Committee shall also designate the institutions to which copies shall be distributed.

LOCAL COMMITTEE.

ART. 32. The Local Committee shall consist of persons interested in the objects of the Association and residing at or near the place of the proposed meeting. It is expected that the Local Committee, assisted by the officers of the Association, will make all essential arrangements for the meeting, and issue a circular giving necessary particulars, at least one month before the meeting.

LIBRARY OF THE ASSOCIATION.

ART. 33. All books and pamphlets received by the Association shall be in the charge of the Permanent Secretary, who shall have a list of the same printed and shall furnish a copy to any member or fellow on application. Members and fellows who have paid their assessments in full shall be allowed to call for books and pamphlets, which shall be delivered to them at their expense, on their giving a receipt agreeing to make good any loss or damage and to return the same free of expense to the Secretary at the time specified in the receipt given. All books and pamphlets in circulation must be returned at each meeting. Not more than five books, including volumes, parts of volumes, and pamphlets, shall be held at one time by any member or fellow. Any book may be withheld from circulation by order of the Standing Committee.

Admission Fee and Assessments.

Art. 34. The admission fee for members shall be five dollars in addition to the annual assessment. On the election of any member as a fellow an additional fee of two dollars shall be paid.

Art. 35. The annual assessment for members and fellows shall be three dollars.

Art. 36. Any member or fellow who shall pay the sum of fifty dollars to the Association, at any one time, shall become a Life Member and as such shall be exempt from all further assessments, and shall be entitled to the Proceedings of the Association. All money thus received shall be invested as a permanent fund, the income of which shall be used only to assist in original research, unless otherwise directed by unanimous vote of the Standing Committee.

Art. 37. All admission fees and assessments must be paid to the Permanent Secretary, who shall give proper receipts for the same.

Accounts.

Art. 38. The accounts of the Permanent Secretary and of the Treasurer shall be audited annually, by Auditors appointed by the Standing Committee.

Alterations of the Constitution.

Art. 39. No part of this Constitution shall be amended or annulled, without the concurrence of three-fourths of the members and fellows present in General Session, after notice given at a General Session of a preceding meeting of the Association.

ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

1. The retiring President introduces the President elect, who takes the chair.
2. Formalities of welcome of the Association as may be arranged by the Local Committee.
3. Report of the list of papers entered and their reference to the Sections.
4. Other reports.
5. Announcements of arrangements by the Local Committee.
6. Election of members.
7. Election of fellows.
8. Unenumerated business.
9. Adjournment to meet in Sections.

This order, so far as applicable, to be followed in subsequent General Sessions.

MEMBERS

OF THE

AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.[1]

PATRONS.[2]

THOMPSON, MRS. ELIZABETH, Stamford, Conn. (22).
LILLY, GEN. WILLIAM, Mauch Chunk, Carbon Co., Pa. (28).

MEMBERS.[3]

Abbot, Miss Elizabeth O., 16 Clark St., Cincinnati, Ohio (20).
Abbot, S. L., M. D., 90 Mt. Vernon St., Boston, Mass. (29).
Abbott, Dr. Chas. C., Trenton, N. J. (29).
Abbott, E. K., M. D., Salinas, Monterey Co., Cal. (29).
Abert, S. Thayer, 1907 Pennsylvania Avenue, Washington, D. C. (30).
Acker, E. O'C., Ass't Eng'r, U. S. N., Norristown, Pa. (28).
Adams, Frank, 41 McGill College Avenue, Montreal, Can. (29).
Adams, John S., M. D., Oakland, Cal. (29).
Adams, Julius W., 155 Congress St., Brooklyn, N. Y. (29).
Agard, Dr. A. H., 1259 Alice St., Oakland, Alameda Co., Cal. (28).
Aikin, Prof. W. E. A., Baltimore, Md. (12).
Allen, Edmund T., 419 Olive St., St. Louis, Mo. (27).
Allen, Dr. G. M., 102 Clark St., Cincinnati, Ohio (30).
Allen, Dr. Harrison, 117 South 20th St., Philadelphia, Pa. (29).

[1] The numbers in parentheses indicate the meeting at which the member was elected. The Constitution requires that the names of all members two or more years in arrears shall be omitted from the list, but their names will be restored on payment of arrearages. Members not in arrears are entitled to the annual volume of Proceedings bound in paper. The payment of ten dollars at one time entitles a member to the subsequent volumes bound in cloth, or by the payment of twenty dollars, to the volumes bound in half morocco.

[2] Persons contributing one thousand dollars or more to the Association are classed as Patrons, and are entitled to the privileges of members and to the publications. The names of Patrons are to remain permanently on the list.

[3] Any Member or Fellow may become a Life Member by the payment of fifty dollars. The money derived from Life Memberships is invested as a fund, the income of which is to be used only to aid in original research. Life Members are exempt from the annual assessment, and are entitled to the annual volume. The names of Life Members are printed in small capitals in the regular list of Members and Fellows.

Allen, Horatio, South Orange, N. J. (29).
Allen, J. M., Hartford, Conn (22).
Allen, Hon. Thomas, St. Louis, Mo. (27).
Alling, Miss Mary R., Cairo, N. Y. (29).
Allis, Solon M., Tucson, Arizona (29).
Alvord, Henry E., C. E., Easthampton, Mass. (29).
Ammen, Rear Admiral Daniel, U. S. Navy, Washington, D. C. (26).
Anderson, Rev. Joseph, Waterbury, Conn. (29).
Anderson, Newton M., Columbus, Ohio (30).
Andrews, James M., jr., Saratoga Springs, N. Y. (28).
Appleton, Rev. Edw. W., D.D., Ashbourne P. O., Montgomery Co., [Pa. (28).
Armstrong, Lucius H., St. Nicholas, Duval Co., Fla. (30).
Armstrong, Mrs. Lucius H., St. Nicholas, Duval Co., Fla (30).
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Walker, N. B., 19 and 21 Cliff St., New York, N Y. (20).
Wall, John L., 338 Sixth Avenue, New York, N. Y. (27).
Wallace, Wm., Ansonia, Conn. (28).
Walmsley, W. H., 1016 Chestnut St., Philadelphia, Pa. (28).
Walter, Hugo, Mt. Auburn, Cincinnati, Ohio (30).
Walton, Miss Evelyn M., Saugus Centre, Mass. (29).
Walton, James, Barnesville, Belmont Co., Ohio (30).
Walton, Jos. J., Philadelphia, Pa. (29).
Walworth, Rev. Clarence A., Albany, N. Y. (28).
Walworth, Mrs. Ellen Hardin, Saratoga Springs, N. Y (28).
Ward, J. Langdon, 120 Broadway, New York, N. Y. (29).
Ward, Samuel B., M. D., Albany, N. Y. (29).
Wardwell, George J., Rutland, Vt. (20).
Waring, Col. George E., jr., Newport, R. I. (29).
Warner, Mrs. J. D., 199 Baltic St, Brooklyn, N. Y (21).
Warnock, James, 33 Warren St., New York, N. Y. (29).
Warren, Cyrus M., Brookline, Mass. (29).
Warren, G. Washington, 54 Devonshire St., Room 1, Boston, Mass. (18).
Warren, Samuel D., Boston, Mass. (29).
Warren, Mrs. Samuel D, 67 Mt. Vernon St., Boston, Mass. (29).
Warren, Wm. J., Minneapolis, Minn. (30).
Waterhouse, Ai, M. D., Jamestown, N. Y. (29).
Waters, Edwin F., Newton Centre, Mass. (29).
·WATERS, GEO. F., 8 Beacon St., Boston, Mass. (29).
Waters, Jabez M., 9th and Freeman Sts., Cincinnati, Ohio (30).
Weber, H. C., 17 Mc Lemore St., Nashville, Tenn. (30).
Webster, Prof. H. E., Union College, Schenectady, N. Y. (23).
Weist, J. R., M. D., Richmond, Ind. (29).
Weld, Mrs. Amy T., 119 East 23rd St., New York, N. Y. (28).
Weld, W. G., Box 105, Newport, R. I. (23).
Wells, Rev. Martin L., Aurora, Ind. (30).
Wells, Samuel, 81 Pemberton Square, Boston, Mass. (24).
Wendell, Oliver C., Observatory, Cambridge, Mass. (29).
Wendte, Rev. C. W., 325 W. 7th St., Cincinnati, Ohio (29).
Wharton, Jos., Box 2786, Philadelphia, Pa. (29).
Wheeler, Prof. C. G., Univ. of Chicago, Chicago, Ill. (18).
Wheeler, Orlando B., Ass't U. S. Lake Survey, Detroit, Mich. (24).
Wheeler, T. B., M. D., 714 Craig St., Montreal, Canada (11).
Whetstone, John L., N. W. cor. 8th St., and Eggleston Avenue, Cincinnati, Ohio (30).
Whitaker, Prof. Channing, Mass. Inst. Technology, Boston, Mass. (29).
Whitcomb, Wm. W., 106 W. Chester Park, Boston, Mass. (29).

White, Prof. Charles Joyce, Cambridge, Mass. (29).
White, Miss Florence, Pittsfield, Mass. (29).
White, Prof. Frances E., Woman's Med. College, Philadelphia, Pa. (29).
White, Prof. H. C., Univ. of Georgia, Athens, Ga. (29).
White, Prof. I. C., University of W. Va., Morgantown, W. Va. (25).
White, Prof. John W., Harvard College, Cambridge, Mass. (30).
White, LeRoy S., Box 157, Waterbury, Conn. (23).
White, Thomas W., Hernando, De Soto Co., Miss. (28).
Whiting, Henry L., U. S. C. and G. Survey, West Tisbury, Mass. (29).
Whiting, Lewis E., M. D., Saratoga Springs, N. Y. (28).
Whitman, Edmund B., 36 Trowbridge St., Cambridge, Mass. (29).
Whitman, Gilbert P., Manchester, N. H. (30).
Whitney, Mary W., Waltham, Mass (19).
Whitney, Dr. Wm. F., Marlboro St., Boston, Mass. (29).
Wickstead, R. J., LL. D., Ottawa, Province of Ont., Can. (29).
Wiechmann, F. G., 458 Broadway, New York, N. Y. (30).
Wilbour, Mrs Charlotte B., care J. M. Farley, 74 W 35th St., New York, N. Y. (28).
Wilcox, Mary A., Newnham College, Cambridge, Eng. (29).
Wilcox, W. A., Sec'y Boston Fish Bureau, 176 Atlantic Avenue, Boston, Mass. (29).
Wilder, Alex., M. D., 567 Orange St., Newark, N. J (29).
Wilder, Graham, Louisville, Ky. (30).
Wilkinson, Mrs. L. V., Brazeau P. O., Perry Co., Mo. (30).
Willets, Joseph C., Skaneateles, N. Y. (29).
Williams, David, 83 Reade St., New York, N. Y. (29).
Williams, Mrs. Drue S., Greensburg, Decatur Co., Ind. (30).
Williams, Dr. E., 64 W 7th St., Cincinnati, Ohio (30).
Williams, E. B., Strawberry Point, Iowa (24).
Williams, Edward H., jr., Danville, Pa. (25).
Williams, F. H., M. D., 100 Boylston St., Boston, Mass. (29).
Williams, Frank, Buffalo, N Y (25).
Williams, G. Henry, Baltimore, Md. (30).
Williams, H. S., Cornell University, Ithaca, N. Y. (18).
WILLIAMS, P. O., M.D., Watertown, Jefferson Co., N. Y. (24).
Williams, Rev. R. R., Canajoharie, Montgomery Co., N. Y. (28).
Williamson, Lieut. Col. R. S., U. S. Engineers, Light House Engineer, San Francisco, Cal. (12).
Willoughby, Hugh L., Saratoga Springs, N. Y. (28).
Wills, William R., Waltham, Mass. (30).
Willson, Robert W., Cambridge, Mass. (30).
Wilmot, Thos. J., Direct U. S. Cable Co., Rye, N. H. (27).
Wilson, C. H., Rugby, Tenn. (30).
Wilson, H. C., Mt. Lookout, Hamilton Co., Ohio (30).
Wilson, Prof. Hiram A., Saratoga Springs, N. Y. (28).
Wilson, M. C., Florence, Ala. (26).
Wilson, Prof. P. B., 44 Second St., Baltimore, Md. (30).

', Sam'l W., Room 30, Rialto Building, 131 Devonshire cor Milk Boston, Mass. (29).
Justin, Librarian Harvard Univ., Cambridge, Mass. (29).
n, Prof. Chas. H., Richmond College, Richmond, Va. (30).
bee, Frank S., care Witherbees, Sherman & Co., Port Henry, N. Y.).
t, Mrs. Henrietta L. T., Hotel Vendôme, Boston, Mass. (29).
DR. ROBERT W., Jamaica Plain, Mass. (29).
Dr. Wm., Portland, Me. (29).
ary, C. J. H., 131 Devonshire St., Boston, Mass. (29).
'ard, J. J., M. D , Army Medical Museum, Washington, D. C. (28).
ard, Richard W., Ouray, Col. (29).
an, Geo. S., 116 Fulton St., New York, N. Y. (29).
n, T. W. D., Hanover, N. H. (28).
, Rev. Geo. F., Oberlin College, Oberlin, Ohio (29).
, Harrison, Sec'y Wyoming Hist. and Geol. Soc., Wilkes Barré, (29).
, Smithson E., Treasurer's Office, L. M. R. R. Co., Cincinnati, o (30).
Samuel B., Bloomington, Ind. (30).

is, Wm. Jay, M. D., Popular Science Monthly, 549 Broadway, v York, N. Y. (28).
Prof. Andrew H., Hanover, Ind. (30).

yer, Joseph, 147 So. Fourth St., Philadelphia, Pa. (29).
man, Charles D., Buffalo, N. Y. (30).
man, William, Room 22, 142 Dearborn St., Chicago, Ill. (30).
E. Gustav, M. D., Elm St., near 14th, Cincinnati, Ohio (30).
G. A., 11th and Madison Sts., Covington, Ky. (30).

[1267 MEMBERS.]

—The omission of an address in the foregoing list indicates that lette[r] ... were returned as uncalled for. Information of the prese[nt] ...ted by the PERMANENT SECRETARY.

HONORARY FELLOW.[1]

ROGERS, PROF. WILLIAM B., 117 Marlborough St., Boston, Mass. (1.) 1881.

FELLOWS.[2]

Abbe, Prof. Cleveland, Washington, D. C. (16). 1874.
Agassiz, Alex., Curator Mus. Comp. Zool., Cambridge, Mass. (18). 1875.
Allen, Joel A., Mus. Comp. Zoology, Cambridge, Mass. (18). 1875.
Alvord, Benj., Brig. Gen., U. S. Army, 1207 Q St., N. W., Washington, D. C. (17). 1874.
Anthony, Prof. Wm. A., Cornell Univ., Ithaca, N. Y. (28). 1880.
Appleton, Prof. John H., Brown Univ., Providence, R. I. (22). 1874.
Atkinson, Edward, 131 Devonshire St., Boston, Mass. (29). 1881.
Austen, Peter T., Ph. D., Rutgers College, Lock Box No. 2, New Brunswick, N. J. (26). 1879.
Austin, E. P., 46 E. Newton St., Boston, Mass. (18). 1874.

Bailey, Prof. Loring W., University of Fredericton, N. B. (18). 1875.
Bailey, Prof. W. W., Brown University, Providence, R. I. (18). 1874.
Baird, Prof. S. F., Sec'y Smithsonian Inst., Washington, D. C. (1). 1875.
Ballou, Geo. F., Waltham, Mass. (29). 1881.
Bandelier, Ad. F., Highland, Ill. (25). 1879.
BARKER, PROF. G. F., Univ. of Penn., Philadelphia, Pa. (18). 1875.
Barnard, F. A. P., President Columbia College, New York, N. Y. (7). 1874.
Barnard, Gen. J. G., U. S. Army, Army Building, New York, N. Y. (14). 1875.
Barnard, Prof. Wm. S., U. S. Dept. Agric., Washington, D. C. (24). 1880.
Bassett, Homer F., Waterbury, Conn. (23). 1874.
Batchelder, Dr. J. H., Salem, Mass. (18). 1874.
Batchelder, John M., 3 Divinity Avenue, Cambridge, Mass. (8). 1875.
Beal, Prof. Wm. James, Agricultural College, Lansing, Mich. (24). 1880.
Belknap, George E., Capt. U. S. N., Malden, Mass. (29). 1881.
Bell, Dr. Alex. Graham, Cambridge, Mass. (26). 1879.
Bell, Samuel N., Manchester, N. H. (7). 1874.
Bessey, Prof. C. E., Agricultural College, Ames, Iowa (21). 1880.
Bethune, Rev. C. J. S., Trinity Coll. School, Pt. Hope, Canada (18). 1875.
Bickmore, Prof. Albert S., American Museum of Natural History, Central Park, New York. N. Y. (17). 1880.
Blake, Clarence J., M. D., Hotel Berkeley, Boston, Mass. (24). 1877.
Blake, Eli W., New Haven, Conn. (1). 1874.

[1] See ARTICLE VI of the Constitution. [2] See ARTICLE IV of the Constitution.

*** The number in parenthesis indicates the meeting at which the member joined the Association; the date at the end of the line the time when made a Fellow.

When the name is given in small capitals, it designates that the Fellow is also a life member, and is entitled to the Annual Volume of Proceedings.

Blake, Prof. Eli W., jr., Providence, R. I. (15). 1874.
Blake, Francis, jr., U. S. Coast Survey, Newton Lower Falls, Mass. (23). 1874.
BOLTON, DR. H. CARRINGTON, Trinity Coll., Hartford, Conn. (17). 1875.
Boss, Prof. Lewis, Director Dudley Observ., Albany, N. Y. (26). 1878.
Bouvé, Thos. T., Boston Soc. Nat. Hist., Boston, Mass. (1). 1875.
Bowditch, Prof. H. P., Harvard Med. School, Boston, Mass. (28). 1880.
Bowditch, Henry I., M.D., 113 Boylston St., Boston, Mass. (2). 1875.
Bowser, Prof. E. A., Rutgers College, New Brunswick, N. J. (28). 1881.
Brackett, Prof. C. F., College of New Jersey, Princeton, N. J. (19). 1875.
Breneman, A. A., Ithaca, N. Y. (20). 1880.
Brewer, Prof. Wm. H., New Haven, Conn. (20). 1875.
Broadhead, Garland Carr, Pleasant Hill, Cass Co., Mo. (27). 1879.
Brocklesby, Prof. John, Trinity College, Hartford, Conn. (23). 1875.
Brooks, Major Thomas B., Geol. State Surveys, Mich. and Wis., Newburgh, N. Y. (26). 1879.
Bross, Hon. Wm., Chicago, Ill. (7). 1874.
Broun, Prof. W. LeRoy, Vanderbilt Univ., Nashville, Tenn. (25). 1877.
Brown, Robert, jr., Office Gas Light Co , Cincinnati, Ohio (11). 1874.
Brown, Mrs. Robert, jr., Cincinnati, Ohio (17). 1874.
BRUSH, PROF. GEORGE J., Yale College, New Haven, Conn. (4). 1874.
Burgess, Edward, Sec. Natural History Soc., Boston, Mass (22). 1877.
Burnham, S. W., 52 Vincennes Ave., Chicago, Ill. (25). 1877.

Caldwell, Prof. Geo. C., Cornell University, Ithaca, N. Y. (23). 1875.
Canby, Wm. M., 1101 Delaware Avenue, Wilmington, Del. (17). 1878.
Capen, Rev. Francis L., 5 Worcester Sq., Boston, Mass. (23). 1874.
Carhart, Prof. Henry S., Evanston, Ill. (29). 1881.
Carmichael, Prof. Henry, Bowdoin College, Brunswick, Me. (21). 1875.
Carpenter, Lieut. W. L., U. S. A., Dunkirk, N. Y. (24). 1877.
Carr, Lucien, Peabody Mus. Arch. and Ethn., Cambridge, Mass. (25). 1877.
Chadbourne, Prof. P. A., Amherst, Mass. (10). 1875.
Chamberlin, T. C., Beloit College, Beloit, Wis. (21). 1877.
Chandler, Prof. C. F., School of Mines, Columbia Coll., 50th St. cor. 4th Ave., New York, N. Y. (19). 1875.
Chandler, Prof. W. H., The Lehigh Univ , Bethlehem, Pa. (19). 1874.
Chanute, O., care Erie Railway, New York, N. Y. (17). 1877.
Chesbrough, E. S., Chicago, Ill. (2). 1877.
Chickering, Prof. J. W., jr., Deaf Mute College, Washington, D. C. (22). 1877.
Clark, Alvan G., Cambridgeport, Mass. (28). 1880.
Clark, Prof. John E., Mathematics, Yale College, New Haven, Conn. (17). 1875.
Clarke, Prof. F. W., Cincinnati University, Cincinnati, Ohio (18). 1874.
Coffin, Prof. John H. C., U. S. Navy, Washington, D. C. (1). 1874.
Coffin, Prof. Selden J., Ph.D., Lafayette College, Easton, Pa. (22). 1874.

Collett, Prof. John, Chief Indiana Bureau of Statistics of Geology, Indianapolis, Ind. (17). 1874.
Colvin, Verplanck, Supt. N. Y. State Adirondack Survey, Albany, N. Y. (28). 1880.
Comstock, Prof. M. L., Ph. D., Galesburg, Knox Co., Ill. (21). 1874.
Comstock, Prof. Theo. B., Eureka, San Juan Co., Col. (24). 1877.
Cook, Prof. A. J., Agricultural College, Lansing, Mich. (24). 1880.
Cook, Prof. George H., New Brunswick, N. J. (4). 1875.
Cooley, Prof. Le Roy C., Vassar College, Poughkeepsie, N. Y. (19). 1880.
Cope, Prof. Edward D., 2100 Pine St., Philadelphia, Pa. (17). 1875.
Cox, Prof. Edward T., Tucson, Arizona Terr. (19). 1874.
Cox, Hon. Jacob D., 103 Broadway, Cincinnati, Ohio (30). 1881.
Coxe, Eckley B., Drifton, Jeddo P. O., Luzerne Co., Pa. (23). 1881.
Crocker, Susan E., M.D., Lawrence, Mass. (21). 1874.
Crosby, Wm. O., Mass. Inst. Technology, Boston, Mass. (29). 1881.
Cross, Prof. Chas. R., Mass. Inst. Technology, Boston, Mass. (29). 1880.
Cummings, Rev. Joseph, D.D., Pres. Northwestern Univ., Evanston, Ill. (13). 1874.
Curtis, Dr. Josiah, Washington, D. C. (18). 1874.
Cutting, Hiram A., M.D., State Geologist, Lunenburgh, Vt. (17). 1874.

Dall, Mrs. Caroline H., 31st St., Washington, D. C. (18). 1874.
Dall, Wm. H., Smithsonian Institution, Washington, D. C. (18). 1874.
Dana, Edward Salisbury, New Haven, Conn. (23). 1875.
Dana, Prof. James D., New Haven, Conn. (1). 1875.
Danforth, Edward, Dep't of Public Instruction, Elmira, N. Y. (11). 1874.
Davidson, Prof. Geo., Asst. Coast and Geodetic Survey, San Francisco, Cal. (29). 1881.
Dawson, Dr. J. W., Principal McGill Coll., Montreal, Canada (10). 1875.
Day, F. H., M. D., Wauwatosa, Wis. (20). 1874.
Dean, George W., U. S. Coast Survey, Fall River, Mass. (15). 1874.
Dimmock, George, Cambridge, Mass. (22). 1874.
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Dodge, Charles R., Washington, D. C. (22). 1874.
Draper, Dan'l, Ph.D., Director N. Y. Meteorological Observatory, Central Park, 64th St., Fifth Avenue, New York, N. Y. (29). 1881.
Draper, Henry, M.D., 271 Madison Ave., New York, N. Y. (28). 1879.
Drown, Prof. Thos. M., Lafayette College, Easton, Pa. (29). 1881.
Dudley, Wm. L., Miami Med. College, Cincinnati, Ohio (28). 1881.
Dunnington, Prof. F. P., University of Virginia, Va. (26). 1880.
Dutton, Capt. C. E., U. S. Ord. Dep't, Washington, D. C. (23). 1875.
Dwyer, John, M. D., Hartford, Conn. (23). 1874.

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Eastman, Prof. J. R., U. S. Naval Observatory, Washington, D. C. (26). 1879.
Eaton, Prof. D. G., Packer Institute, Brooklyn, N. Y. (19). 1874.

Eddy, Prof. H. T., University of Cincinnati, Cincinnati, Ohio (24). 1875
Edison, Thos. A., Menlo Park, N. J. (27). 1878.
Edmands, J. Rayner, Observatory, Cambridge, Mass (29). 1880.
Egleston, Prof. Thos., School of Mines, Columbia College, New York, N. Y. (27). 1879.
Eimbeck, Wm., U.S.C.S., Washington, D C (17). 1874.
Elliott, Arthur H., School of Mines, Columbia College, New York, N. Y. (23). 1880.
Elliott, Ezekiel B., Treasury Dept., Washington, D. C. (10). 1874.
Elsberg, Louis, M.D., 614 Fifth Avenue, New York, N. Y. (23). 1874.
Emerson, Prof. Benjamin K., Amherst, Mass. (19). 1877.
Emerson, Prof. C. F., Dartmouth College, Hanover, N. H. (22). 1874.
Emerton, James H., Salem, Mass. (18). 1875.
Emmons, S. F., Box 2836, Denver, Col. (26). 1879.
Engelmann, Dr. George, St. Louis, Mo. (1). 1875.
Engelmann, Geo. J., M. D., 3003 Locust St., St. Louis, Mo. (25). 1878.
Eustis, Prof. Henry L., Cambridge, Mass. (2). 1874.
Evans, Asher B., Principal Union School, Lockport, N. Y (19). 1874.

Fairbanks, Henry, Ph. D., St. Johnsbury, Vt. (14). 1874.
Farlow, Dr. W. G., 6 Park Square, Boston, Mass. (20). 1875.
Farmer, Moses G., Torpedo Station, Newport, R. I. (9). 1875.
Farquharson, Dr. Robert James, Des Moines, Iowa (24). 1880.
Ferguson, Maj. Thos. B., Ass't U. S. Fish Commissioner, Washington, D. C. (28). 1881.
Fernald, Prof. Charles H., State Agricultural College, Orono, Me. (22). 1881.
Ferrel, Wm., U. S. Coast Survey Office, Washington, D C. (11) 1875.
Ficklin, Prof. Joseph, Univ. of Missouri, Columbia, Mo. (20). 1878.
Fitch, Edward H., Jefferson, Ashtabula Co., Ohio (11). 1874.
Fitch, O. H., Ashtabula, Ohio (7). 1874.
Fletcher, Dr. Robert, Surgeon General's Office, Washington, D C. (29). 1881.
Foote, Dr. A. E., 1223 Belmont Avenue, Philadelphia, Pa. (21). 1874.
Forbes, Prof. S. A., Normal, Ill. (27). 1879.
Frazer, Prof. Persifor, Ass't Geologist, 2d Geol. Survey of Pa., 917 Clinton St., Philadelphia, Pa. (24). 1879.
Freeman, H. C., Alto Pass, Union Co., Ill (17). 1876.
Frisby, Prof. Edgar, U. S. N. Observ., Washington, D. C. (28). 1880.

Gage, Simon Henry, Ithaca, N. Y. (28). 1881.
Gardiner, Rev. Frederic, D.D., Middletown, Conn. (23). 1874.
Gardner, James T., Director N. Y. State Survey, Albany, N. Y (25). 1879.
Garland, Rev. Dr. L. C., Chancellor Vanderbilt Univ., Nashville, Tenn. (25). 1877.
Garman, S. W., Museum Comp. Zoology, Cambridge, Mass. (20). 1874.
Genth, Prof. F. A., Univ. of Pennsylvania, Philadelphia, Pa. (24). 1875.

Gilbert, G. K., Box 240, Salt Lake City, Utah (18). 1874.
Gillman, Henry, 155 Adams Avenue East, Detroit, Mich. (24). 1875.
Gilman, Daniel C., President of the Johns Hopkins University, Baltimore, Md. (10). 1875.
Goessman, Prof. C. A., Mass. Agric. Coll , Amherst, Mass. (18). 1875.
Goldschmidt, S. A., Ph. D., 59 & 61 Liberty St., New York, N. Y. (24). 1880.
Gooch, Frank A., U. S. Geological Survey, Newport, R. I. (25). 1880.
Goodale, Prof. G. L., Botanic Gardens, Cambridge, Mass. (18). 1875.
Goode, Prof. G. Brown, Curator National Museum, Washington, D. C. (22). 1874.
Goodfellow, Edward, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (24). 1879.
Grant, Mrs Mary J., Brookfield, Conn. (23). 1874.
Gray, Prof. Asa, Botanic Gardens, Cambridge, Mass. (1). 1875.
Green, Traill, M. D., Easton, Pa. (1). 1874.
Grimes, J. Stanley (17). 1874.
Grinnan, A. G., Orange Court House, Va. (7). 1875.
Grote, Aug. R., New Brighton, Staten Island, N. Y. (22). 1875.
Guyot, Prof. Arnold, Princeton, N. J. (1). 1875.

Hagen, Dr Hermann A., Mus. Comp. Zool., Cambridge, Mass. (17) 1875.
Hall, Prof. Asaph, U. S. Naval Observ., Washington, D. C. (25). 1877.
Hall, Edwin H., Johns Hopkins Univ., Baltimore, Md. (29). 1881.
Hall, Prof. James, Albany, N. Y. (1). 1875.
Hamlin, Dr. A. C., Bangor, Me. (10). 1874.
Harger, Oscar, Yale College Museum, New Haven, Conn. (25). 1879.
HARKNESS, PROF. WM., U. S. N., U. S. Observatory, Washington, D. C. (26). 1878.
Harrington, Prof. Mark W., Ann Arbor, Mich. (22). 1875.
Harrison, Dr. B. F., Wallingford, Conn. (11). 1874.
Hasbrouck, Prof. I. E., Rutgers Coll., New Brunswick, N. J. (23). 1874.
Haskins, Rev. David Greene, Cambridge, Mass. (25). 1874.
Hastings, C. S., Johns Hopkins University, Baltimore, Md. (25). 1878.
Hawes, Dr George W., National Museum, Washington, D. C. (23). 1875.
Hedrick, B. S., Exam'r U. S. Pat. Office, Washington, D. C. (19). 1874.
Henderson, John G., Winchester, Ill. (25). 1879.
Henshaw, Henry W., Care Major J. W. Powell, 910 M St., Washington, D. C. (24). 1877.
Herrick, Mrs. Sophie B. (23). 1877.
Hervey, Rev. A. B., Taunton, Mass. (22) 1879.
Hilgard, Prof. E. W., Univ. of California, Berkeley, Cal. (11). 1874.
Hilgard, Prof. J. E., U. S. Coast Survey, Washington, D. C. (4). 1874.
Hill, George W., Nautical Almanac Office, Navy Department, Washington, D. C. (23). 1874.
Hill, Rev. Dr. Thomas, 68 Deering St., Portland, Me. (8). 1875.
Hill, Walter N., Chester, Pa. (29). 1881.

Hinrichs, Prof. Gustavus, State University, Iowa City, Iowa (17). 1874
Hitchcock, Prof. Charles H., Hanover, N. H. (11). 1874.
Hoffman, Dr. Fred., 797 Sixth Ave., New York, N. Y. (28). 1881.
Holden, Prof. E. S., Director Washburn Observatory, Univ. of Wisconsin, Madison, Wis (23). 1875.
Holmes, Dr. Oliver Wendell, 296 Beacon St., Boston, Mass. (29). 1881.
Horsford, Prof. E. N., Cambridge, Mass. (1). 1876.
Hough, Franklin B., Lowville, N. Y. (4). 1874.
Hoy, Philo R., M.D., Racine, Wis. (17). 1875.
Hunt, George, Providence, R. I. (9). 1874.
Hunt, Dr. T. Sterry, Montreal, Canada (1). 1874.
Huntington, Prof. J. H., Box 1914, Boston, Mass. (19). 1874.
Hyatt, Prof. Alpheus, Natural History Society, Boston, Mass. (18). 1875.
Hyatt, James, Stanfordville, Duchess Co., N. Y. (10). 1874.
Hyde, Prof. E. W., Walnut Hills, Cincinnati, Ohio (25). 1881.

Jeffries, B. Joy, M. D., 15 Chestnut St., Boston, Mass. (29). 1881.
Jenks, Elisha T., Middleborough, Mass. (22). 1874.
Jenks, Prof. J. W. P., Middleborough, Mass. (2). 1874.
Jillson, Dr. B. C., Pittsburgh, Pa. (14). 1881.
Johnson, Prof. S. W., Sheffield Sci. School, New Haven, Conn. (22). 1874.
Johnson, Prof. W. W., Annapolis, Md. (29). 1881.
Joy, Prof. Charles A., Stockbridge, Mass. (8). 1879.
Julien, A. A., School of Mines, Columbia Coll., New York, N. Y. (24). 1875.

Kedzie, Prof. Robert C., Lansing, Mich. (29). 1881.
Kerr, Prof. W. C., Raleigh, N. C. (10). 1874.
Kirkwood, Prof. Daniel, Bloomington, Ind. (7). 1874.

Lambert, Rev. Thomas R., D.D., Charlestown, Mass. (18). 1874.
Langley, Prof. J. W., Univ. of Michigan, Ann Arbor, Mich. (23). 1875.
Langley, Prof. S. P., Director of Observatory, Allegheny, Pa. (18). 1874.
Lattimore, Prof. S. A., Univ. of Rochester, Rochester, N. Y (15). 1874.
Lawrence, George N., 45 E 21st St., New York, N. Y. (7). 1877.
Lea, Dr. Isaac, 1622 Locust St., Philadelphia, Pa. (1). 1875.
LeConte, Dr. John L., 1625 Spruce St , Philadelphia, Pa. (1). 1874.
LeConte, Prof. Joseph, Univ. of Cal., Berkeley, Cal. (29). 1881.
Ledoux, Albert R., Ph. D., 17 Cedar St., New York, N. Y. (26). 1881.
Leeds, Prof. Albert R., Stevens Institute, Hoboken, N. J. (23). 1874.
Leonard, N. R., State University, Iowa City, Iowa (21). 1875.
Lesley, Prof. J. Peter, State Geol. of Pa., 1008 Clinton St., Philadelphia, Pa. (2). 1874.
Lewis, Prof. Henry C., E. Washington Lane, Germantown, Pa. (26). 1880.
Lindsley, Dr. J. Berrien, Nashville, Tenn. (1). 1874.
Lintner, J. A., N. Y. State Mus. of Nat. Hist., Albany, N. Y. (22). 1874.
Little, W. C., Albany, N. Y. (22). 1874.
Litton, Abram, Washington University, St. Louis, Mo. (28). 1879.

Lockwood, Rev. Samuel, Freehold, Monmouth Co., N. J. (18). 1875.
Loomis, Prof. Elias, New Haven, Conn. (1). 1874.
Lord, Prof. Nat. W., State Univ., Columbia, Ohio (29). 1881.
Loughridge, Prof. R. H., Berkeley, Cal. (21). 1874.
Lovering, Prof. Joseph, Harvard University, Cambridge, Mass. (2). 1875.
Lull, Edward P., Commander U. S. N., Sitka, Alaska (28). 1880.
Lupton, Prof. N. T., Vanderbilt University, Nashville, Tenn. (17). 1874.
Lyle, David Alexander, Lieut. U. S. A., Ordnance Department, National Armory, Springfield, Mass. (28). 1880.
Lyman, Prof. Chester S., New Haven, Conn. (4). 1875.
Lyman, Col. Theodore, Brookline, Mass. (23). 1875.
Lyon, Dr. Henry, 34 Monument Sq., Charlestown, Mass. (18). 1874.

Mabery, C. F., Cambridge, Mass. (29). 1881.
Mallery, Brevet Lieut. Col. Garrick, U. S. Army, Box 585, Washington, D. C. (26). 1879.
Mann, B. Pickman, Ass't Entomologist, U. S. Dep't of Agric., Washington, D. C. (22). 1874.
Marcy, Oliver, LL.D., Evanston, Ill. (10). 1874.
Mark, Edw. L., 48 Shepard St., Cambridge, Mass. (21). 1879.
Markoe, Geo. F. H., 61 Warren St., Roxbury, Mass. (29). 1881.
MARSH, PROF. O. C., Yale College, New Haven, Conn. (15). 1874.
Martin, Prof. Daniel S., Rutgers Female College, New York, N. Y. (23). 1879.
Martin, Prof. H. Newell, Johns Hopkins Univ., Baltimore, Md. (27). 1880.
Mason, Prof. Otis T., Columbian University, Washington, D. C. (25). 1877.
Mayer, Prof. A. M., So. Orange, N. J. (19). 1874.
McCauley, Capt. C. A. H., Ass't Q. M., U. S. A., 321 Michigan Ave., Chicago, Ill. (29). 1881.
McMurtrie, William, Dep't Agriculture, Washington, D. C. (22). 1874.
Means, A., D.D., LL.D., Oxford, Ga. (5). 1877.
Meehan, Thomas, Germantown, Pa. (17). 1875.
Mees, Carl Leo, Louisville, Ky. (24). 1876.
Mendenhall, Prof. T. C., Columbus, Ohio (20). 1874.
Merriman, C. C., Rochester, N. Y. (29). 1880.
Michelson, A. A., Master U. S. N., Nautical Almanac Office, Washington, D. C. (26). 1879.
Minot, Charles Sedgwick, Roslindale P. O., Boston, Mass. (28). 1880.
Mitchell, Miss Maria, Vassar College, Poughkeepsie, N. Y. (4). 1874.
Moore, Prof. J. W., M. D., Lafayette College, Easton, Pa. (22). 1874.
Morley, Prof. Edward W., Hudson, Ohio (18). 1876.
Morris, Rev. John G., Baltimore, Md. (12). 1874.
Morse, Prof. E. S., Salem, Mass. (18). 1874.
Morton, H., Stevens Institute Technology, Hoboken, N. J. (18). 1875.
Munroe, Prof. C. E., U. S. Naval Academy, Annapolis, Md. (22). 1874.

Nason, Prof. H. B., Rensselaer Polytechnic Inst., Troy, N. Y. (13). 1874.
Nelson, Prof. Edward T., Delaware, Delaware Co., Ohio (24). 1877.
Newberry, Prof. J. S., Cleveland, Ohio, and Columbia College, New York, N. Y. (5). 1875.
Newcomb, Prof. S., U. S. Naval Observ., Washington, D. C. (13). 1874.
Newton, Hubert A., New Haven, Conn. (6). 1874.
Nichols, Prof. W. R., Mass. Inst. Technology, Boston, Mass. (18). 1875.
Niles, Prof. W. H., Cambridge, Mass. (16). 1874.
Nipher, Prof. F. E., Washington University, St. Louis, Mo. (24). 1876.
Norton, Prof. W. A., New Haven, Conn. (6). 1875.
Norwood, Charles J., Ass't Kentucky Geological Survey, Russellville, Ky. (26). 1881.

Oliver, Prof. James E., Cornell University, Ithaca, N. Y. (7). 1875.
Oliver, Miss Mary E., Cascadilla Hotel, Ithaca, N. Y. (20). 1874.
Ordway, Prof. John M., Mass. Inst. Technology, Boston, Mass. (9). 1875.
Orton, Prof. Edward, President Ohio Agricultural and Mechanical College, Columbus, Ohio (19). 1875.
Osborne, J. W., 212 Delaware Ave. N. E., Washington, D. C. (22). 1874.
Owen, Dr. Richard, New Harmony, Ind. (20). 1874.

Paine, Cyrus F., Rochester, N. Y. (12). 1874.
Paine, Nathaniel, Worcester, Mass. (18). 1874.
Palfray, Hon. Charles W., Salem, Mass. (21). 1874.
Parke, John G., Lt. Col. Corps of Eng'rs, Bv't Maj. Gen. U. S. A., Office of Chief of Engineers, Washington, D. C. (29). 1881.
Parkhurst, H. M., Law Stenographer, 31 Park Row, New York, N. Y. (23). 1874.
Peckham, S. F., Providence, R. I. (18). 1875.
Pedrick, Wm. R., Lawrence, Mass. (22). 1875.
Peirce, B. O., Beverly, Mass. (18). 1874.
Perkins, Maurice, Schenectady, N. Y. (15). 1875.
Peter, Dr. Robert, Ky. Geol. Survey, Lexington, Ky. (29). 1881.
Pettee, Prof. William H., Ann Arbor, Mich. (24). 1875.
Phillips, A. W., New Haven, Conn. (24). 1879.
Phippen, Geo. D., Salem, Mass. (18). 1874.
Pickering, Prof. E. C., Director of Observ., Cambridge, Mass. (18). 1875.
Potter, Prof. William B., Washington University, St. Louis, Mo. (25). 1879.
Powell, Major J. W., U. S. Geologist, 910 M St., Washington, D. C. (23). 1875.
Prescott, Prof. Albert B., Ann Arbor, Mich. (23). 1875.
Prime, Frederick, jr., Allentown Iron Co., 230 So. 3d St., Philadelphia, Pa. (24). 1875.
Pritchett, Henry S., Morrison Observatory, Glasgow, Mo. (29). 1881.
Pulsifer, Wm. H., St. Louis, Mo. (26). 1879.

Pumpelly, Prof. Raphael, U. S. Geol. Survey, Newport, R. I. (17). 1875.
Putnam, F. W., Curator Peabody Museum Archæology and Ethnology, Cambridge, Mass. Address as Permanent Secretary A. A. A. S., Salem, Mass. (10). 1874.
Putnam, James J., M. D., 63 Marlborough St., Boston, Mass. (28). 1880.

Quimby, Prof. E. T., Hanover, N. H. (22). 1874.
Quincy, Edmund, 88 Clinton St., Boston, Mass. (11). 1874.

Rauch, Dr. John H., Chicago, Ill. (11). 1875.
Raymond, Rossiter W., 17 Burling Slip, New York, N. Y. (15). 1875.
Redfield, J. H., care A. Whitney & Sons, Philadelphia, Pa. (1). 1874.
Rees, Prof. John K., Washington University, St. Louis, Mo. (26). 1878.
Remsen, Prof. Ira, Johns Hopkins University, Baltimore, Md. (22). 1875.
Rice, John M., U. S. Naval Academy, Annapolis, Md. (25). 1881.
Rice, Prof. Wm. North, Middletown, Conn. (18). 1874.
Richards, Prof. Robert H., Mass. Inst. Tech., Boston, Mass. (22). 1875.
Richards, Mrs. Robert H., Mass. Inst. of Tech., Boston, Mass. (23). 1878.
Ricketts, Pierre de Peyster, Ph.D., School of Mines, Columbia College, New York, N. Y. (26). 1880.
RILEY, PROF. C. V., U. S. Entomologist, 1700 13th St. N.W., Washington, D. C. (17). 1874.
Ritchie, E. S., 150 Tremont St., Boston, Mass. (10). 1877.
Rockwood, Prof. Charles G., jr., Princeton, N. J. (20). 1874.
Rogers, Fairman, 202 West Rittenhouse Square, Philadelphia, Pa. (11). 1874.
Rogers, Prof. Robert E., Jefferson Medical College, Philadelphia, Pa. (18). 1874.
Rogers, W. A., Ass't Harvard College Observ., Cambridge, Mass. (15). 1875.
Rominger, Dr. Carl, Ann Arbor, Mich. (21). 1879.
Rood, Prof. O. N., Cor. E. 49th St. & Madison Ave., New York, N. Y. (14). 1875.
Roosevelt, Clinton, 11 Wall St., New York, N. Y. (11). 1874.
Runkle, Prof. J. D., Mass. Inst. of Tech., Boston, Mass. (2). 1875.
Rutherford, Lewis M., 175 Second Ave., New York, N. Y. (13). 1875.

Sadtler, Prof. S. P., University of Pa., Philadelphia, Pa. (22). 1875.
Safford, Dr. James M., Nashville, Tenn. (6). 1875.
Sampson, Comdr. W. T., U. S. N., Naval Observatory, Washington, D. C. (25). 1881.
Saunders, William, London, Ontario, Canada (17). 1874.
Schott, Charles A., U. S. Coast and Geodetic Survey Office, Washington, D. C. (8). 1874.
Schweitzer, Prof. Paul, State Univ. of Mo., Columbia, Mo. (24). 1877.
SCUDDER, SAMUEL H., Cambridge, Mass. (18). 1874.

Seaman, W. H., Microscopist, 1424 11th St. N. W., Washington, D. C. (23). 1874.
Sheafer, P. W., Pottsville, Pa. (4). 1879.
Sias, Solomon, M.D., Schoharie, Schoharie Co., N. Y. (10). 1874.
Sill, Hon. Elisha N., Cuyahoga Falls, Ohio (6). 1874.
Silliman, Prof. Benj., Yale College, New Haven, Conn. (1). 1874.
Silliman, Prof. Justus M., Lafayette College, Easton, Pa. (19). 1874.
Skinner, Joseph J., New Britain, Conn. (28). 1880.
Smith, Prof. E. A., University of Alabama, Tuscaloosa, Ala. (20). 1877.
Smith, Mrs. Erminnie A., 203 Pacific Ave., Jersey City, N. J. (25). 1880.
Smith, Prof. F. H., University of Virginia, Charlottesville, Va. (26). 1880.
Smith, Dr. J. Lawrence, Louisville, Ky. (1). 1874.
Smith, Quintius C., M. D., Box 707, Austin, Texas (26). 1881.
Smith, Prof. S. I., Yale College, New Haven, Conn. (18). 1875.
Smock, Prof. John Conover, Rutgers College, New Brunswick, N. J. (23). 1879.
Snow, Prof. F. H., Lawrence, Kan. (29). 1881.
Spencer, John W., Geol., Paxton, Sullivan Co., Ind. (20). 1874.
Springer, Dr. Alfred, Box 573, Cincinnati, Ohio (24). 1880.
Stanard, Benjamin A., Cleveland, Ohio (6). 1874.
Stearns, Henry P., M.D., Hartford, Conn. (23). 1874.
Stearns, R. E. C., Box 13, Berkeley, Cal. (18). 1874.
Steiner, Dr. Lewis H., Frederick City, Md. (7). 1874.
Stephens, W. Hudson, Lowville, N. Y. (18). 1874.
Sternberg, George M., Surgeon U.S.A., Care Surgeon General, U.S.A., Washington, D. C. (24). 1880.
Stockwell, John N., 579 Case Avenue, Cleveland, Ohio (18). 1875.
Stone, Mrs. Leander, 3352 Indiana Avenue, Chicago, Ill. (22). 1874.
Stone, Ormond, Director Cincinnati Observatory, Univ. of Cincinnati, Mt. Lookout, Ohio (24). 1876.
Storrs, Henry E., Jacksonville, Ill. (20). 1874.
Story, Wm. E., Johns Hopkins Univ., Baltimore, Md. (29). 1881.
Stuart, Prof. A. P. S., Lincoln, Nebraska (21). 1874.
Sutton, Dr. George, Aurora, Dearborn Co., Ind. (20). 1881.
Swallow, Prof. G. C., Columbia, Mo. (10). 1875.

Tainter, Sumner, 1221 Connecticut Ave., Washington, D. C. (29). 1881.
Tappan, Prof. Eli T., Kenyon College, Gambier, Ohio (20). 1874.
Taylor, Wm. B., Smithsonian Institution, Washington, D. C. (29). 1881.
Terry, Prof. N. M., U. S. Naval Academy, Annapolis, Md. (23). 1874.
Thompson, A. Remsen, 50 West 51st Street, New York, N. Y. (1). 1874.
Thurston, Prof. R. H., Stevens Institute, Hoboken, N. J. (23). 1875.
Townshend, Prof. N. S., Columbus, Ohio (17). 1881.
Tracy, Sam'l M., Columbia, Boone Co., Mo. (27). 1881.
Trembley, J. B., M D., Oakland, Alameda Co., Cal. (17). 1880.
Trowbridge, Prof. John, Harvard University, Cambridge, Mass. (25). 1876.

Trowbridge, Prof. W. P., New Haven, Conn. (10). 1874.
Tuttle, Prof. Albert H., Columbus, Ohio (17). 1874.

Uhler, Philip R., Baltimore, Md. (19). 1874.
Upham, Warren, Nashua, N. H. (25). 1880.

Van der Weyde, P. H., M. D., Box 3619, New York, N. Y. (17). 1874.
Van Vleck, Prof. John M., Middletown, Conn. (23). 1875.
VAUX, WILLIAM S., 1702 Arch St., Philadelphia, Pa. (1). 1875.
Verrill, Prof. A. E., Yale College, New Haven, Conn. (16). 1875.

Wadsworth, M. Edward, Ph. D., Assistant in Lithology, Museum of Comparative Zoology, Cambridge, Mass. (23). 1874.
Waldo, Leonard, S. D., New Haven, Conn. (28). 1880.
Walker, Prof. J. R., 154 Canal St., New Orleans, La. (19). 1874.
Walker, Prof. Joseph B., care Bank of Kentucky, Louisville, Ky. (20). 1874.
WALLER, E., School of Mines, Columbia College, New York, N. Y. (23). 1874.
Walling, H. F., U. S. Coast and Geodetic Survey Office, Washington, D. C. (16). 1874.
Ward, Prof. Henry A., Rochester, N. Y. (13). 1875.
Ward, Lester F., U. S. Geological Survey, Washington, D. C. (26). 1879.
Ward, Dr. R. H., 53 Fourth St., Troy, N. Y. (17). 1874.
Warder, Prof. Robert B., North Bend, Hamilton Co., Ohio (19). 1881.
WARNER, JAMES D., 199 Baltic St., Brooklyn, N. Y. (18). 1874.
Warren, Gen. G. K., U.S.A., Engineer's Office, Newport, R. I. (12). 1875.
Warren, Prof. S. Edward, Newton, Mass. (17). 1875.
Watson, Sereno, Botanic Gardens, Cambridge, Mass. (22). 1875.
Wead, Prof. Charles K., Univ. of Michigan, Ann Arbor, Mich. (23). 1880.
Webster, Prof. N. B., Principal Webster Inst., Norfolk, Va. (7). 1874.
Wells, Daniel H., Hartford, Conn. (18). 1875.
Westcott, O. S., Racine, Wis. (21). 1874.
Wheatland, Dr. Henry, President Essex Inst., Salem, Mass. (1). 1874.
Wheeler, Capt. Geo. M., U. S. E., Lock Box 93, Washington, D. C. (25). 1879.
Wheildon, W. W., Concord, Mass. (13). 1874.
White, Prof. C. A., Le Droit Park, Washington, D. C. (17). 1875.
Whitfield, R. P., American Museum Natural History, 77th St. & 8th Avenue, New York, N. Y. (18). 1874.
Whitman, Chas. O., care G. F. Leonard, Newton Highlands, Mass. (27). 1880.
Whitney, Solon F., Watertown, Mass. (20). 1874.
Whittlesey, Col. Charles, Historical Rooms, Cleveland, Ohio (1). 1875.
Wilber, G. M., Pine Plains, N. Y. (19). 1874.
Wilbur, A. B., Port Jervis, Orange Co., N. Y. (23). 1874.

Wilder, Prof. Burt G., Cornell University, Ithaca, N. Y. (22). 1875.
Wiley, Prof. Harvey W., Purdue Univ., Lafayette, Ind. (21). 1874.
Williams, Charles H., M.D., 15 Arlington St., Boston, Mass. (22). 1874.
Williams, Prof. Henry W., 15 Arlington St., Boston, Mass. (11). 1874.
Wilson, Prof. Daniel, President University College, 117 Bloor St., Toronto, Canada (25). 1876.
Winchell, Prof. Alex., Ann Arbor, Mich. (8). 1875.
Winchell, Prof. N. H., Univ. of Minnesota, Minneapolis, Minn. (19). 1874.
Woerd, Chas. V., Am. Watch Co., Waltham, Mass. (29). 1881.
Wood, Prof. De Volson, Hoboken, N. J. (29). 1881.
Wormley, T. G., Univ. of Pennsylvania, Philadelphia, Pa. (20). 1878.
Worthen, A. H., Springfield, Ill. (5). 1874.
Wright, Prof. Albert A., Oberlin College, Oberlin, Ohio (24). 1880.
Wright, Prof. Arthur W., Yale College, New Haven, Conn. (14). 1874.
Würtele, Rev. Louis C., Acton Vale, Province of Quebec, Can. (11). 1875.
Wyckoff, Wm. C., 44 Howard St., New York, N. Y. (20). 1874.
Wylie, Prof. Theoph. A., Indiana Univ., Bloomington, Ind. (20). 1874.

Yarrow, Dr. H. C., care Army Med. Mus., Washington, D. C. (23). 1874.
Youmans, Prof. Edward L., New York, N. Y. (6). 1874.
Young, C. A., Prof. of Astronomy, College of New Jersey, Princeton, N. J. (18). 1874.

[432 FELLOWS.]

TOTAL NUMBER OF MEMBERS OF THE ASSOCIATION, 1699.

DECEASED MEMBERS.

[Information respecting omissions in this list, and the date of birth and of decease of any of the former members, is requested by the Permanent Secretary.]

Abbe, George W., New York, N. Y. (23). Died Sept. 25, 1879.

Abert, J. J., Washington, D. C. (1). Born in 1785. Died January 27, 1863.

Adams, C. B., Amherst, Mass. (1). Born January 11, 1814. Died Jan'y 19, 1853.

Adams, Edwin F., Charlestown, Mass. (18).

Adams, Samuel, Jacksonville, Ill. (18). Born Dec. 19, 1806. Died April 29, 1877.

Agassiz, Louis, Cambridge, Mass. (2). Born May 28, 1807. Died Dec. 14, 1873.

Ainsworth, J. G., Barry, Mass. (14).

Allen, Zachariah, Providence, R. I. (1). Died in March, 1882.

Allston, R. F. W., Georgetown, S. C. (3). Born April 21, 1801. Died April 7, 1864.

Andrews, E. B., Lancaster, Ohio (7).

Anthony, Charles H., Albany, N. Y. (6). Died in 1874.

Ames, N. P., Springfield, Mass. (1). Born in 1803. Died April 23, 1847.

Appleton, Nathan, Boston, Mass. (1). Born Oct. 6, 1779. Died July 14, 1861.

Armstrong, John W., Fredonia, N. Y. (24).

Atwater, Mrs. S. T., Chicago, Ill. (17). Born Aug. 8, 1812. Died April 11, 1878.

Bache, Alexander D., Washington, D. C. (1). Born July 19, 1806. Died Feb. 17, 1867.

Bache, Franklin, Philadelphia, Pa. (1). Born Oct. 25, 1792. Died March 19, 1864.

Bailey, Jacob W., West Point, N. Y. (1). Born April 29, 1811. Died Feb. 26, 1857.

Bardwell, F. W., Lawrence, Kan. (13). Died in 1878.

Barrett, Moses, Milwaukee, Wis. (21). Died in 1873.

Beck, C. F., Philadelphia, Pa. (1).

Beck, Lewis C., New Brunswick, N. J. (1). Born Oct. 4, 1798. Died April 21, 1853.

Beck, T. Romeyn, Albany, N. Y. (1). Born Aug. 11, 1791. Died Nov. 19, 1855.

Belt, Thomas, London, Eng. (27). Died Sept. 8, 1878.

Benedict, G. W., Burlington, Vt. (16).

Bicknell, Edwin, Boston, Mass. (18). Born in 1830. Died March 19, 1877.

Binney, Amos, Boston, Mass. (1). Born Oct. 18, 1803. Died Feb. 18, [1847.
Binney, John, Boston, Mass. (3).
Blackie, Geo. S., Nashville, Tenn. (26).
Blake, Homer C., New York, N. Y. (28). Born Feb. 1, 1822.
Blanding, William, ——, R. I. (1).
Blatchford, Thomas W., Troy, N. Y. (6).
Blatchley, Miss S. L., New Haven, Conn. (19).
Boadle, John, Haddonfield, N. J. (20). Born in 1805. Died in July, 1878.
Bomford, George, Washington, D. C. (1). Born 1780. Died March 25, 1848.
Bowron, James, South Pittsburg, Tenn. (26). Died in Dec., 1877.
Bradley, Leverette, Jersey City, N. J. (15). Died in 1875.
Braithwaite, Jos., Chambly, C. W. (11).
Briggs, Albert D., Springfield, Mass. (13). Died Feb. 20, 1881.
Brigham, Charles H., Ann Arbor, Mich. (17). Born July 27, 1820. Died in Jan., 1879.
Brown, Andrew, Natchez, Miss. (1).
Burnap, G. W., Baltimore, Md. (12). Born Nov. 20, 1802. Died Sept. 8, 1859.
Burnett, Waldo I., Boston, Mass. (1). Died July 1, 1854, aged 27.
Butler, Thomas B., Norwalk, Conn. (10).

Cairns, F. A., New York, N. Y. (27). Died in 1879.
Carpenter, Thornton, Camden, S. C. (7).
Carpenter, William M., New Orleans, La. (1).
Case, Leonard, Cleveland, Ohio (15). Born 1820. Died 1880.
Case, William, Cleveland, Ohio (6).
Caswell, Alexis, Providence, R. I. (2). Born Jan. 29, 1799. Died Jan. 8, 1877.
Chapman, N., Philadelphia, Pa. (1). Born May 28, 1780. Died July 1, [1853.
Chase, S., Dartmouth, N. H. (2).
Chauvenet, William, St. Louis, Mo. (1). Born May 24, 1819. Died Dec. 13, 1870.
Clapp, Asahel, New Albany, Ind. (1). Born Oct. 5, 1792. Died Dec. 15, 1862.
Clark, Henry James, Cambridge, Mass. (13). Died July 1, 1873, aged 47.
Clark, Joseph, Cincinnati, Ohio (5).
Clarke, A. B., Holyoke, Mass. (13).
Cleaveland, C. H., Cincinnati, Ohio (9).
Cleveland, A. B., Cambridge, Mass. (2).
Coffin, James H., Easton, Pa. (1). Born Sept. 6, 1806. Died Feb. 6, 1873.
Cole, Thomas, Salem, Mass. (1). Born Dec. 24, 1779. Died June 24, 1852.
Coleman, Henry, Boston, Mass. (1).
Collins, Frederick, Washington, D. C. (28). Born Dec. 5, 1842. Died Oct. 27, 1881.
Conrad, Timothy Abbott, Philadelphia, Pa. (1). Born in August, 1803. Died August 9, 1877.

Cooke, Caleb, Salem, Mass. (8). Born Feb. 15, 1838. Died June 5, 1880.
Cooper, William, Hoboken, N. J. (9). Died in 1864.
Corning, Erastus, Albany, N. Y. (6). Born Dec. 14, 1794. Died April 9, 1872.
Couper, J. Hamilton, Darien, Ga. (1).
Cramp, J. M., Wolfville, N. S. (11). Born July 25, 1796. Died Dec. 6, 1881.
Crocker, Charles F., Lawrence, Mass. (22). Died in July, 1881.
Crosby, Alpheus, Salem, Mass. (10). Born Oct. 13, 1810. Died Apr. 17, 1874.
Crosby, Thomas R., Hanover, N. H. (18).
Croswell, Edwin, Albany, N. Y. (6). Born May, 1797. Died June 13, 1871.
Curry, W. F., Geneva, N. Y. (11).

Dalrymple, E. A., Baltimore, Md. (11). Died Oct. 30, 1881.
Dayton, Edwin A., Madrid, N. Y. (7). Born in 1827. Died June 24, 1878.
Dean, Amos, Albany, N. Y. (6). Born Jan. 16, 1803. Died Jan. 26, 1868.
Dearborn, George H. A. S., Roxbury, Mass. (1).
Dekay, James E., New York, N. Y. (1). Born 1792. Died Nov. 21, 1851.
DeLaski, John, Carver's Harbor, Me. (18).
Dewey, Chester, Rochester, N. Y. (1). Born Oct. 25, 1781. Died Dec. 15, 1867.
Dexter, G. M., Boston, Mass. (11).
Dillingham, W. A. P., Augusta, Me. (17).
Doggett, Wm. E., Chicago, Ill. (17). Born Nov. 20, 1820. Died in 1876.
Doolittle, L., Lenoxville, C. E. (11). Died in 1862.
Dorr, E. P., Buffalo, N. Y. (25). Died March 28, 1881.
Ducatel, J. T., Baltimore, Md. (1).
Duffield, George, Detroit, Mich. (10). Born July 4, 1794. Died June 26, 1869.
Dumont, A. H., Newport, R. I. (14).
Duncan, Lucius C., New Orleans, La. (10).
Dunn, R. P., Providence, R. I. (14).

Easton, Norman, Fall River, Mass. (14).
Eaton, James H., Beloit, Wis. (17). Died Jan. 5, 1877.
Ely, Charles Arthur, Elyria, Ohio (4).
Emerson, Geo. B., Boston, Mass. (1). Born Sept 12, 1797. Died March 4, 1881.
Emmons, Ebenezer, Williamstown, Mass. (1). Born May 16, 1799. Died October 1, 1863.
Engstrom, A. B., Burlington, N. J. (1).
Everett, Edward, Boston, Mass. (2). Born April 11, 1794. Died Jan. 15, 1865.
Ewing, Thomas, Lancaster, Ohio (5). Born Dec. 28, 1789. Died Oct. 26, 1871.

Faries, R. J., Wauwatosa, Wis. (21). Died May 31, 1878.
Ferris, Isaac, New York, N. Y. (6). Born Oct. 9, 1798. Died June 16, 1873.
Feuchtwanger, Lewis, New York, N. Y. (11). Died in 1876.
Fillmore, Millard, Buffalo, N. Y. (7). Born Jan. 7, 1800. Died March 8, 1874.
Fisher, Mark, Trenton, N. J. (10).
Fitch, Alexander, Hartford, Conn. (1). Born March 25, 1799. Died Jan. 20, 1859.
Forbush, E. B., Buffalo, N. Y. (15).
Force, Peter, Washington, D. C. (4). Born Nov. 26, 1790. Died Jan. 23, 1868.
Ford, A. C., Nashville, Tenn. (26).
Forshey, Caleb G., New Orleans, La. (21). Died in Aug., 1881.
Foster, J. W., Chicago, Ill. (1). Born in 1815. Died June 29, 1873.
Foucon, Felix, Madison, Wis. (18).
Fowle, Wm. B., Boston, Mass. (1). Born Oct. 17, 1795. Died Feb. 6, 1865.
Fox, Charles, Grosse Ile, Mich. (7).
Frazer, John F., Philadelphia, Pa. (1).
French, J. W., West Point, N. Y. (11).

Gavit, John E., New York, N. Y. (1).
Gay, Martin, Boston, Mass. (1). Died Jan. 12, 1850, aged 46.
Gibbon, J. H., Charlotte, N. C. (3).
Gillespie, W. M., Schenectady, N. Y. (11). Born in 1816. Died Jan'y 1, 1868.
Gilmor, Robert, Baltimore, Md. (1).
Gould, Augustus A., Boston, Mass. (11). Born April 23, 1805. Died Sept. 15, 1866.
Gould, B. A., Boston, Mass. (2). Born June 15, 1787. Died Oct. 24, 1859.
Graham, James D., Washington, D. C. (1). Born in 1799. Died Dec. 28, 1865.
Gray, Alonzo, Brooklyn, N. Y. (13). Born in 1808. Died March 10, 1860.
Gray, James H., Springfield, Mass. (6).
Greene, Benjamin D., Boston, Mass. (1). Died Oct. 14, 1862, aged 68.
Greene, Everett W., Madison, N. J. (10). Died in 1864.
Greene, Samuel, Woonsocket, R. I. (9). Died in 1868.
Greer, James, Dayton, Ohio (20).
Griffith, Robert E., Philadelphia, Pa. (1).
Griswold, John A., Troy, N. Y. (19). Born in 1822. Died Oct. 31, 1872.
Guest, William E., Ogdensburg, N. Y. (6).

Hackley, Charles W., New York, N. Y. (4). Born March 9, 1809. Died January 10, 1861.
Hadley, George, Buffalo, N. Y. (6). Born June, 1813. Died Oct. 16, 1877.
Haldeman, S. S., Chickies, Pa. (1). Died Sept. 10, 1880, aged 68.
Hale, Enoch, Boston, Mass. (1). Born Jan. 29, 1790. Died Nov. 12, 1848.

Hance, Ebenezer, Fallsington P. O., Pa. (7). Died in 1876.
Hare, Robert, Philadelphia, Pa. (11). Born Jan. 17, 1781. Died May 15, 1858.
Harlan, Joseph G., Haverford, Pa. (8).
Harlan, Richard, Philadelphia, Pa. (1).
Harris, Thaddeus W., Cambridge, Mass. (1). Born Nov. 12, 1795. Died Jan. 16, 1856.
Harrison, A. M., Plymouth, Mass. (29).
Harrison, Jos., jr., Philadelphia, Pa. (12).
Hart, Simeon, Farmington, Conn. (1).
Hartt, Charles F., Ithaca, N. Y. (18). Born in 1840. Died March 18, 1878.
Haven, Joseph, Chicago, Ill. (17). Born Jan. 4, 1816. Died May 23, 1874.
Hayden, H. H., Baltimore, Md. (1).
Hayward, James, Boston, Mass. (1). Died July 27, 1866, aged 80.
Henry, Jos., Washington, D. C. (1). Born Dec. 17, 1797. Died May 13, 1878.
Hickox, S. V. R., Chicago, Ill. (17). Died in 1872.
Hilgard, Theo. C., St. Louis, Mo. (17). Born Feb. 28, 1828. Died Mch. 5, 1875.
Hincks, William, Toronto, C. W. (11).
Hitchcock, Edward, Amherst, Mass. (1). Born May 24, 1793. Died Feb. 27, 1864.
Hodgson, W. B., Savannah, Ga. (10). Born 1815.
Holbrook, John E., Charleston, S. C. (1). Born Dec. 31, 1796. Died Sept. 8, 1871.
Hopkins, Albert, Williamstown, Mass. (19). Died May 25, 1872, aged 64.
Hopkins, James G., Ogdensburg, N. Y. (10). Died in 1860.
Hopkins, T. O., Williamsville, N. Y. (10). Died in 1866.
Hopkins, Wm., Lima, N. Y. (5.) Died in March, 1867.
Horton, C. V. R., Chaumont, N. Y. (10). Died in 1862.
Horton, William, Craigville, N. Y. (1).
Hosford, Benj. F., Haverhill, Mass. (13). Died in 1864.
Houghton, Douglas, Detroit, Mich. (1). Born Sept. 21, 1809. Died Oct. 13, 1845.
Hovey, Edmund O., Crawfordsville, Ind. (20). Born July 15, 1801. Died March 10, 1877.
Howland, Theodore, Buffalo, N. Y. (15).
Hubbert, James, Richmond, Province of Quebec (16). Died in 1868.
Hunt, Edward B., Washington, D. C. (2). Born in 1822. Died Oct. 2, 1863.
Hunt, Freeman, New York, N. Y. (11). Born March 21, 1804. Died March 2, 1858.

Ives, Moses B., Providence, R. I. (9). Died in 1857.
Ives, Thomas P., Providence, R. I. (10).

Jackson, Charles T., Boston, Mass. (1). Born June 21, 1805. Died Aug. 29, 1880.

James, Thomas Potts, Cambridge, Mass. (22). Born Sept. 1, 1803. Died Feb. 22, 1882.
Johnson, Walter R., Washington, D. C. (1). Born June 21, 1794. Died April 26, 1852.
Jones, Catesby A. R., Washington, D. C. (8).
Jones, James H., Boston, Mass. (28).

Kedzie, W. K., Oberlin, Ohio (25).
Keely, G. W., Waterville, Me. (1).
Keep, N. C., Boston, Mass. (13). Died in 1875.
Kennicott, Robert, West Northfield, Ill. (12).
King, Mitchell, Charleston, S. C. (3). Born June 8, 1783. Died in 1862.
Klippart, John H., Columbus, Ohio (17). Died October, 1878.
Knickerbocker, Charles, Chicago, Ill. (17). Died in 1873.
Knight, J. B., Philadelphia, Pa. (21). Died March 10, 1879.

Lacklan, R., Cincinnati, Ohio (11).
Lapham, Increase A., Milwaukee, Wis. (3). Born Mch. 7, 1811. Died Sept. 14, 1875.
LaRoche, R., Philadelphia, Pa. (12).
Lasel, Edward, Williamstown, Mass. (1).
Lawford, Frederick, Montreal, Canada (11). Died in 1866.
Lederer, Baron von, Washington, D. C. (1).
Lieber, Oscar M., Columbia, S. C. (8). Born Sept. 8, 1830. Died June 27, 1862.
Lincklaen, Ledyard, Cazenovia, N. Y. (1).
Linsley, James H., Stafford, Conn. (1). Born May 5, 1787. Died Dec. 26, 1843.
Lockwood, Moses B., Providence, R. I. (9). Died in 1872.
Logan, William E., Montreal, Canada (1). Born April 23, 1798. Died June 22, 1875.
Loosey, Charles F., New York, N. Y. (12).
Lothrop, Joshua R., Buffalo, N. Y. (15).
Lyon, Sidney S., Jeffersonville, Ind. (20). Born Aug. 4, 1808. Died June 24, 1872.

Maack, G. A., Cambridge, Mass. (18).
Mahan, Dennis H., West Point, N. Y. (9). Born April 2, 1802. Died Sept. 16, 1871.
Marsh, Dexter, Greenfield, Mass. (1).
Marsh, James E., Roxbury, Mass. (10).
Mather, William W., Columbus, Ohio (1). Born May 24, 1804. Died Feb. 27, 1859.
Maude, John B., St. Louis, Mo. (27). Died in April, 1879.
Maupin, S., Charlottesville, Va. (10).
McMahon, Mathew, Albany, N. Y. (11).
M'Conihe, Isaac, Troy, N. Y. (5).
Meade, George G., Philadelphia, Pa. (15). Born Dec. 30, 1815. Died Nov. 6, 1872.

Meek, F. B., Washington, D. C. (6). Born December 10, 1817. Died December 21, 1876.

Meigs, James Aitken, Philadelphia, Pa. (12). Born July 30, 1829. Died Nov. 9, 1879.

Minifie, William, Baltimore, Md. (12). Born in 1805. Died Oct. 24, 1880.

Mitchel, O. M., Cincinnati, Ohio (3). Born Aug. 28, 1810. Died Oct. 30, 1862.

Mitchell, William, Poughkeepsie, N. Y. (8). Died in 1869.

Mitchell, Wm. H., Florence, Ala. (17).

Morgan, Lewis H., Rochester, N. Y. (10). Died Dec. 17, 1881.

Morris, John B., Nashville, Tenn. (26).

Morton, Samuel G., Philadelphia, Pa. (1). Born Jan. 26, 1799. Died May 15, 1851.

Mudge, Benjamin F., Manhattan, Kansas (25). Born Aug. 11, 1817. Died Nov. 21, 1879, aged 62 years.

Munroe, Nathan, Bradford, Mass. (6). Born May 16, 1804. Died July 8, 1866.

Munroe, William, Concord, Mass. (18). Died April 27, 1877.

Newland, John, Saratoga Springs, N. Y. (28). Died Jan. 18, 1880.

Newton, E. H., Cambridge, N. Y. (1).

Nichols, C. A., Providence, R. I. (17). Died in 1877.

Nicholson, Thomas, New Orleans, La. (12).

Nicollett, Jean N., Washington, D. C. (1). Born July 24, 1786. Died Sept. 11, 1843.

Norton, John P., New Haven, Conn. (1). Born in 1822. Died Sept. 5, [1852.

Noyes, J. O., New Orleans, La. (21).

Nutt, Cyrus, Bloomington, Ind. (20). Died in 1875.

Oakes, Wm., Ipswich, Mass. (1). Born July 1, 1799. Died July 31, 1848.

Ogden, Robert W., New Orleans, La. (21). Died March 24, 1878.

Ogden, William B., High Bridge, Westchester Co., N. Y. (17). Born in 1805. Died Aug. 3, 1877.

Olmsted, Alexander F., New Haven, Conn. (4).

Olmsted, Denison, New Haven, Conn. (1). Born June 18, 1791. Died May 13, 1859.

Olmsted, Denison, jr., New Haven, Conn. (1).

Otis, George Alexander, Washington, D. C. (10). Born Nov. 12, 1830. Died Feb. 23, 1881.

Painter, Jacob, Lima, Pa. (23). Died in 1876.

Painter, Minshall, Lima, Pa. (7).

Parker, Wilbur F., West Meriden, Conn. (23). Died in 1876.

Parkman, Samuel, Boston, Mass. (1). Died Dec. 15, 1854, aged 38.

Payn, Charles H., Saratoga Springs, N. Y. (28). Born May 16, 1814. Died Dec. 20, 1881.

Peirce, Benjamin, Cambridge, Mass. (1). Born April 4, 1809. Died Oct. 6, 1880.

Perkins, George R., Utica, N. Y. (1). Born May 3, 1812. Died Aug. 22, 1876.

Perkins, Henry C., Newburyport, Mass. (18). Born Nov. 13, 1804. Died Feb. 2, 1873.

Perry, John B., Cambridge, Mass. (16). Died Oct. 3, 1872, aged 52.

Perry, M. C., New York, N. Y. (10).

Piggot, A. Snowden, Baltimore, Md. (10).

Plumb, Ovid, Salisbury, Conn. (9).

Pope, Charles A., St. Louis, Mo. (12). Born May 15, 1818. Died July 6, 1870.

Porter, John A., New Haven, Conn. (14). Born March 15, 1822. Died Aug. 25, 1866.

Pourtalès, Louis François de, Cambridge, Mass. (1). Born in 1822. Died July 18, 1880.

Pruyn, John V. L., Albany, N. Y. (1). Born in 1806. Died Nov. 22, 1877.

Pugh, Evan, Centre Co., Pa. (14).

Putnam, Mrs. F. W., Cambridge, Mass. (19). Born Dec. 29, 1838. Died March 10, 1879.

Putnam, J. Duncan, Davenport, Iowa. (27). Born Oct. 18, 1855. Died Dec. 10, 1881.

Read, Ezra, Terra Haute, Ind. (20). Died in 1877.

Redfield, William C., New York, N. Y. (1). Born March 26, 1789. Died Feb. 12, 1857.

Resor, Jacob, Cincinnati, Ohio (8). Died in 1871.

Robb, James, Fredericton, N. B. (4).

Robinson, Coleman T., Buffalo, N. Y. (15).

Rockwell, John A., Norwich, Conn. (10). Born August 27, 1803. Died February 10, 1861.

Rogers, Henry D., Glasgow, Scotland (1). Born 1809. Died May 29, 1866.

Rogers, James B., Philadelphia, Pa. (1). Born February 22, 1803. Died June 15, 1852.

Root, Elihu, Amherst, Mass. (25).

Sager, Abram, Ann Arbor, Mich. (6). Born December 22, 1810. Died August 6, 1877.

Schaeffer, Geo. C., Washington, D. C. (1). Died in 1873.

Scott, Joseph, Dunham, C. E. (11). Died in 1865.

Senter, Harvey S., Aledo, Ill. (20). Died in 1875.

Seward, William H., Auburn, N. Y. (1). Born May 16, 1801. Died Oct. 10, 1872.

Sheppard, William, Drummondville, Province of Quebec, Can. (11). Born in 1783. Died in 1867.

Sherwin, Thomas, Dedham, Mass. (11). Born March 26, 1799. Died July 23, 1869.

Silliman, Benjamin, New Haven, Conn. (1). Born August 8, 1779. Died November 22, 1864.

Skinner, John B., Buffalo, N. Y. (15). Died in 1871.

Slack, J. H., Philadelphia, Pa. (12).

Smith, David P., Springfield, Mass. (29). Died in Dec. 1880.
Smith, J. V., Cincinnati, Ohio (5).
Smith, James Y., Providence, R. I. (9). Born September 15, 1809. Died in 1876.
Smith, Lyndon A., Newark, N. J. (9). Born November 11, 1795. Died December 15, 1865.
Snell, Ebenezer S., Amherst, Mass. (2). Born October 7, 1801. Died in September, 1877.
Sparks, Jared, Cambridge, Mass. (2). Born May 10, 1789. Died March 14, 1866.
Spinzig, Charles, St. Louis, Mo. (27). Died Jan. 22, 1882.
Stimpson, William, Chicago, Ill. (12). Died May 26, 1872.
Stone, Samuel, Chicago, Ill. (17). Died in 1876.
Sullivant, Wm. S., Columbus, Ohio (7). Born Jan. 15, 1803. Died April 30, 1873.
Swain, James, Fort Dodge, Iowa (21). Born in 1816. Died in 1877.

Tallmadge, James, New York, N. Y. (1).
Taylor, Richard C., Philadelphia, Pa. (1). Born January 18, 1789. Died November 26, 1851.
Tenney, Sanborn, Williamstown, Mass. (17). Born in January, 1827. Died July 11, 1877.
Teschemacher, J. E., Boston, Mass. (1). Died Nov. 9, 1853, aged 63.
Thompson, Alexander, Aurora, N. Y. (6).
Thompson, Zadock, Burlington, Vt. (1). Born May 23, 1796. Died Jan. 19, 1856.
Thurber, Isaac, Providence, R. I. (9).
Tillman, Samuel D., Jersey City, N. J. (15). Died in 1875.
Tolderoy, James B., Fredericton, N. B. (11).
Torrey, John, New York, N. Y. (1). Born August 15, 1796. Died March 10, 1873.
Torrey, Joseph, Burlington, Vt. (2). Born Feb. 2, 1797. Died Nov. 26, 1867.
Totten, Joseph G., Washington, D. C. (1). Born August 23, 1788. Died April 22, 1864.
Townsend, Howard, Albany, N. Y. (10). Died in 1867.
Townsend, John K., Philadelphia, Pa. (1).
Townsend, Robert, Albany, N. Y. (9). Died in 1866.
Troost, Gerard, Nashville, Tenn. (1). Born March 15, 1776. Died Aug. 14, 1850.
Tuomey, Michael, Tuscaloosa, Ala. (1). Born September 29, 1805. Died March 20, 1857.
Tyler, Edward R., New Haven, Conn. (1).

Vancleve, John W., Dayton, Ohio (1).
Vanuxem, Lardner, Bristol, Pa. (1).

Wadsworth, James S., Genesee, N. Y. (2). Born October 30, 1807. Died May 8, 1864.

Wagner, Tobias, Philadelphia, Pa. (9).
Walker, Joseph, Oxford, N. Y. (10).
Walker, Sears C., Washington, D. C. (1). Born March 28, 1805. Died January 30, 1853.
Walker, Timothy, Cincinnati, Ohio (4). Born Dec. 1, 1802. Died Jan. 15, 1856.
Walsh, Benjamin D., Rock Island, Ill. (17).
Wanzer, Ira, Brookfield, Conn. (18). Born April 17, 1796. Died March 5, 1879.
Warren, John C., Boston, Mass. (1). Born Aug. 1, 1778. Died May 4, 1856.
Watertown, Charles, Wakefield, Eng. (1).
Watkins, Samuel, Nashville, Tenn. (26).
Watson, J. Craig, Ann Arbor, Mich. (13). Born Jan. 28, 1838. Died Nov. 23, 1880.
Webster, H. B., Albany, N. Y. (1).
Webster, J. W., Cambridge, Mass. (1). Died Aug. 30, 1850, aged 57.
Webster, M. H., Albany, N. Y. (1).
Weed, Monroe, Wyoming, N. Y. (6). Died in 1867.
Weyman, G. W., Pittsburg, Pa. (6). Died in 1864.
Wheatland, Richard H., Salem, Mass. (18). Born July 6, 1830. Died Dec. 21, 1863.
Wheeler, Arthur W., Baltimore, Md. (29). Born March, 1859. Died Jan. 6, 1881.
White, Samuel S., Philadelphia, Pa. (23). Died Dec. 30, 1879.
Whitman, Wm. E., Philadelphia, Pa. (23). Died in 1875.
Whitney, Asa, Philadelphia, Pa. (1). Born Dec. 1, 1791. Died June 4, 1874.
Whittlesey, Charles C., St. Louis, Mo. (11). Died in 1872.
Willard, Emma, Troy, N. Y. (15). Born Feb. 23, 1787. Died April 15, 1870.
Wilson, W. C., Carlisle, Pa. (12).
Winlock, Joseph, Cambridge, Mass. (5). Born Feb. 6, 1826. Died June 11, 1875.
Woodbury, Levi, Portsmouth, N. H. (1). Born Dec. 22, 1789. Died Sept. 4, 1851.
Woodman, John S., Hanover, N. H. (11). Born in 1819. Died May 15, 1871.
Wright, John, Troy, N. Y. (1).
Wyman, Jeffries, Cambridge, Mass. (1). Born Aug. 11, 1814. Died Sept. 4, 1874.

Yarnall, M., Washington, D. C. (26). Born in 1817. Died Jan. 27, 1879.
Young, Ira, Hanover, N. H. (7).

[334 DECEASED MEMBERS.]

REPORTS OF COMMITTEES.

REPORT OF THE COMMITTEE ON STANDARDS OF STELLAR MAGNITUDE.

IN selecting a series of stars as standards of stellar magnitude, it would obviously be impossible to choose those which should represent any assigned brightness. Stars could not be found which should have magnitudes of exactly, 1.0, 2.0, 3.0, etc. If the scale was made to conform to the stars, subsequent measures would be sure to show that its divisions were irregular. Moreover, an observer might have difficulty in determining fractions of a magnitude, if the light of all his comparison stars were expressed as integer numbers. A much more precise method seems to be, first, to select suitable stars as standards; secondly, to measure their relative light; and, thirdly, to express these measures in terms of any convenient scale of magnitudes that may be finally adopted. Subsequent measures will then serve to increase the accuracy with which this scale is defined, by determining more precisely the brightness of the comparison stars.

International coöperation is to be desired in order that the system recommended may be adopted by astronomers in all parts of the world. Accordingly, the Royal Astronomical Society and the Astronomische Gesellschaft were invited to aid in this work. A committee consisting of Messrs. Hind, Knobel, Knott, Stone and Christie was appointed by the Royal Astronomical Society, and Dr. Schönfeld was named as its representative by the Astronomische Gesellschaft. Unfortunately, the somewhat voluminous correspondence of your committee has been delayed by the great distances to be traversed, and although the following plans are under consideration by the committees named above, final action has not yet been taken. Stars may be conveniently divided according to their brightness into three classes:—

I. Lucid stars, or those brighter than the sixth magnitude. These stars will form the standards of comparison of the brighter variable stars, and in general for all observations made with the unaided eye or with an opera or field glass. Most of the photometric measures hitherto made relate to these stars.

II. Bright telescopic stars, from the sixth to the tenth magnitude. This class includes most of the catalogue stars, and will furnish the standards for the fainter variables. Meridian observations and those with small telescopes are in general directed towards these objects.

III. Faint telescopic stars, fainter than the tenth magnitude. Large telescopes are required for the convenient study of these stars. They will form convenient standards for the asteroids, for very faint variables, and for the components of clusters, etc.

It is proposed that the first of these classes be assigned to the Royal Astronomical Society, the second to the Astronomische Gesellschaft and the third to the American Association. In accordance with this scheme the following plan is recommended fon the fainter stars.

The standard stars to be so selected that they will form twenty-four groups near the equator and at approximately equal intervals in right ascension. Each group to consist of a series of stars decreasing in brightness by differences of about half a magnitude, from the tenth magnitude to the faintest object visible in the largest telescopes. The groups to be located by bringing a star visible to the naked eye into the field of the telescope, waiting for two minutes, and then forming a chart of the zone ten minutes wide passing through the centre of the field of the telescope during the next four minutes. This zone will therefore be defined as the region from five minutes north to five minutes south of the bright star, and from two to six minutes following it. The stars to be selected from this zone, which may in some cases have to be extended. Care to be taken that no star is near enough to another to be sensibly affected in apparent brightness by its proximity. The following stars are proposed as leading stars for these groups: —

γ *Pegasi*, θ' *Ceti*, α *Piscium*, α *Ceti*, γ *Eridani*, α *Tauri*, ϵ *Orionis*, γ *Geminorum*, α *Canis Minoris*, ϵ *Hydræ*, α *Leonis*, θ *Leonis*, η *Virginis*, α *Virginis*, α *Bootis*, β *Libræ*, δ *Ophiuchi*, η *Ophiuchi*, η *Serpentis*, δ *Aquilæ*, θ *Aquilæ*, β *Aquarii*, α *Aquarii* and α *Pegasi*.

Two other groups formed of stars near the poles to be added to these, with which all may be compared, to avoid large systematic errors in different right ascensions.

The advantages of this system are that an observer in any part of the earth and at any season will find comparison stars conveniently situated for observation. Moreover, he will often be able to bring some of the standard stars into the field without moving the dome or reading the finding circles of his instrument. This is a great advantage when working with a large telescope with which alone the smaller stars can be observed. The leading stars will also form convenient standards in observing the others photometrically. For this reason none fainter than the third or fourth magnitude have been selected.

If the above plans are adopted, Dr. C. H. F. Peters will undertake the preparation of charts of the small zones. By the help of these the standards will be selected and their positions determined. Measures of their light will then, if desired, be undertaken at the Harvard College Observatory. It is greatly to be hoped that similar measures may also be made at some other Observatories, and if possible by different methods. The owners of very large telescopes are also invited to examine these regions and locate very faint stars which may be beyond the reach of the other instruments employed in this work.

When the measurements are completed the light of all the standards selected will be expressed in such a scale as may seem best. Any observer may then compare the scale he is accustomed to use with this, by estimating the light of a number of comparison stars. Uniformity may thus be secured where discrepancies amounting to several magnitudes now occur.

Respectfully submitted,

EDWARD C. PICKERING, Chairman.
LEWIS BOSS,
S. W. BURNHAM,
ASAPH HALL,
WILLIAM HARKNESS,
EDWARD S. HOLDEN,
SIMON NEWCOMB,
C. H. F. PETERS,
ORMOND STONE,
C. A. YOUNG.

Preliminary Reports of the Committee on Standard Time.[1]

Majority Report.

A majority of the Committee on Standard Time, present at this meeting, report that they are firmly convinced that the adoption of a single standard for the whole country would be advantageous, both from a scientific and economic point of view. If, however, it should not be found practicable to accomplish this result immediately, we believe it is desirable to reduce the number of standards as soon as possible by the adoption of uniform standards over large areas, these standards to differ from some principal standard by an even number of hours. The committee realize that it would be impossible to bring about such a result without the active co-operation of the transportation companies, and have been in correspondence upon the subject with the principal railroads of the country. As this correspondence is still in progress, it is requested that the committee be given further time, and that an additional member be added from Canada.

Respectfully submitted,
Ormond Stone,
J. R. Eastman,
H. S. Pritchett.

Cincinnati, August, 1881.

Minority Report.

The views expressed in the committee meetings regarding the expediency of the plans considered for reducing the number of local times now in use in different parts of the United States, have revealed so considerable a difference of opinion as to the ultimate end to be achieved, that it seems to me wise to place on record the opinion held by the minority of the committee present at this time.

[1] It was agreed that these reports should be printed, and that a time should be set apart at the Montreal Meeting for special discussion of papers and reports on Standard Time.

This is perhaps the more important, since it may reasonably be presumed that the opinions expressed would be sanctioned by some of the now absent members of the committee, and I am assured by the distinguished gentlemen with whom I am associated in this matter, that they deem it advisable that a complete expression of opinion should be presented by the committee to the Association in regard to this matter.

I beg leave therefore to formulate, at this time, the two propositions, on which, in the opinion of the minority, any scheme for reducing the number of standards of time in the United States should be made to depend:

1st. The extent of the United States in longitude is too great to be governed by a single standard of time.

2nd. The transportation companies of a given district and the communities through which they pass ought to be governed by the same standard of time.

For the proper application of these two principles to any scheme which is to be submitted to the Association for its endorsement, it is necessary that a full session and considerable opportunity for discussion should be afforded to your committee. These conditions may be fulfilled at the Montreal meeting.

The complications arising, from having the transportation companies governed by one time and the community governed by another, have shown themselves so great that, except for special reasons in particular cases, the community adopts the time of the transportation company with which it is most connected. If this company's time differs several hours from the true local time, then the local time is arbitrarily supplanted by a time which rudely disturbs the historical and firmly seated prejudices of the large majority of the population in regard to the hours of beginning, intermitting and ending their avocations. If a uniform time for all transportation companies should be adopted, and to avoid the evil described the local time of contiguous cities should not be discouraged, then the confusion arising from a constantly differing local time, as compared with the transportation company's time would be not less than now exists.

In order that it may be clearly understood to what, in the opinion of the minority, the above considerations would naturally lead, I have appended the two following resolutions, to some modi-

fied form of which at some future meeting, I hope the attention of the Association may be directed.

Resolved, That the object immediately held in view shall be the adoption of a series of time standards in which each one shall differ by exactly one hour from that preceding and from that following it, and that these standards have names easily remembered by the populace.

Resolved, That in consideration of the difficulties of altering popular usages at once, that the standard of time for the eastern part of the country be that of the commercial metropolis, New York city. That the second standard of time, which would be for the Mississippi Valley, be that of the city of St. Louis. It is to be understood, however, that so soon as the difficulties of introducing these time standards shall have been so far overcome that the populace depends on the observatories for their time, that such an arrangement be made between the eastern and western observatories concerned that the difference between the times issued for the two localities specified shall be accurately fixed at one hour. This change may or may not be attended with the fixing of the eastern standard at five hours west of Greenwich.

Respectfully submitted,
LEONARD WALDO.

Cincinnati, August, 1881.

SECTION A.

MATHEMATICS, PHYSICS AND CHEMISTRY.

PAPERS READ.

On the Effect of Prolonged Stress upon the Strength and Elasticity of Pine Timber. By Robert H. Thurston, of Hoboken, N. J.

In papers read before the American Society of Civil Engineers at various dates, the writer has given the results of investigations made to determine the behavior of metals under loads of varying magnitude and under intermitted stresses, and to ascertain in what cases and under what conditions the variation, with period of stress, of the normal line of elastic limits, discovered and announced by him in the year 1873, occurs in practice.

Experiments made by Mr. Herman Haupt, forty years ago, revealed a fact not even now generally understood and appreciated —that *timber* may be injured by a prolonged stress far within that which leaves the material uninjured when the test is made in the usual way and occupies a few minutes only.

Thus, using pieces $60 \times 3 \times 1$ inches ($152.4 \times 7.62 \times 2.54$ cm.) set as cantilevers with a breaking moment, due the load, of $Pl=48$ inch-pounds (.55 kilogrammetres) he obtained for the value of $R=\frac{6\,wl}{b\,d^2}$ the following figures:

Kind of Wood.	*R.*	*Time.*	*Remark.*
White Pine,	2272	10 minutes.	Injured.
" "	1548	16 days.	"
Hemlock,	2624	5 minutes.	"
"	1620	16 days.	"
Yellow Pine,	2848	5 minutes.	"
" "	1800	16 days.	"
Locust,	5504	2 minutes.	Not injured.
"	3600	3½ days.	Injured.
"	2304	16 days.	"
White Oak,	4248	16 minutes.	Not injured.
" "	7200	15 minutes.	Injured.
" "	3648	40 hours.	Not injured.
" "	4088	48 hours.	Injured.

All samples tested were considered good selected timber.

An extended series of experiments made intermittently in the mechanical laboratory of the Stevens Institute of Technology, Department of Engineering, during some years past, had included an examination of this subject and the result has confirmed Haupt's earlier work and has given a tolerably good idea of the effect of prolonged stress in modifying the primitive relation of stress and strain where the wood is good southern yellow pine.

A selected yellow pine plank was obtained for test, the history of which was known. The stick was cut at Jacksonville, Fla., in October, 1879, was received early in the following year and was piled in the yard, air-seasoning, until taken for test in the spring of 1880. The plank measured 4 in.$\times$12 in.$\times$24 ft. (10.16$\times$30.48$\times$731.52 cm.) When tested, it had been seasoning six months, the latter part of the time indoors.

From the middle of this plank a stick was first cut 3 in. $\times$3 in.$\times$24 ft. (7.62$\times$7.62$\times$731.5 cm.) and from this was cut a set of ten pieces from 40 to 54 in. long (101.6 to 137.2 cm.) and from 1¼ to 3 in. square in cross-section (3.16 to 7.62 cm.) square. These latter pieces were tested under various conditions, as then reported, to determine the values of their moduli of elasticity and rupture.

The moduli of rupture were usually 11,000 to 12,000 for the expression $R=\frac{3}{2}\frac{Pl}{bd^2}$ (in metric measure, 773.3 to 843.6) and the moduli of elasticity ranged from two and a quarter millions (in metric measure, $10^6\times1406$ to $158175+10^4$). In specific gravity the wood ranged from 0.75 to 1.00, usually about 0.85. When kiln-dried to a moderate extent, the density was but little altered, if at all, but the modulus of elasticity rose to two and a half millions (17375 $\times$by 10^3) and the modulus of rupture was increased about 20 per cent.

From the previously unused part of the plank a set of three test pieces was cut about one inch (2.54 cm.) square in section and tested on supports 40 inches (101.6 cm.) apart, to determine their breaking loads. The result is shown in detail in the appended table. In these specimens the annual rings were in the cross-section of each piece, indicated by lines making angles of 45° with the edges. These pieces broke at 345, 380 and 410 pounds respectively. The weakest piece broke by splintering, and had it been as sound as the others would probably also have sustained a somewhat heavier load. As will be seen by comparison

with the other and with subsequent tests, the deflection of the strongest piece in the set is exceptionally small and the piece probably exceptionally strong and stiff. We may, therefore, take 375 pounds (170 kilog.) or a trifle over, as a good average for loads breaking pieces of this size.

Nine other pieces were cut and dressed to the same size and were mounted on supports 40 in. apart, in a frame arranged for the purpose in the workshop of the Institute, in three sets of three each. These sets were loaded thus:

1st set,	250 pounds (113.6 kilog.);	Table 2.
2nd set,	300 pounds (136.4 kilog.);	Table 3.
3rd set,	350 pounds (158.1 kilog.);	Table 4.

Or to about 60, 80 and 95 per cent. of their probable maximum strength, as indicated by ordinary test of the companion lot above described. Their deflections were measured when set, and at intervals subsequently, by means of an accurate micrometer reading to ten-thousandths of an inch.

The whole set of bars, loaded most heavily as above, broke within two days; one bar yielding, as shown in Table 2, at the end of a period included between observations taken at 4½ and 13½ hours from the beginning, the second breaking at some time between 27 and 30½ hours and the third giving way at the end of 43 hours. A load of 87½ per cent., the maximum obtained by usual methods of test, is thus shown to be capable of breaking the piece under the conditions here described, and an apparent "factor of safety" of 1¼ is evidently not a factor of safety at all when time is given for the piece to yield.

The second set, loaded with 0.75 the maximum momentary weight, all broke, as is shown by Table 3, one at the end of about 3½ days, another after 5 days, and the third at the end of a little more than a month. It is probable that these differences of time are due to differences of strength more than to variations of the effect of time of stress. A "factor of safety" of 1⅓ is evidently not a real factor of safety for wood in such cases as this.

The behavior of the third and last set of test pieces is shown in Table 4. These pieces were loaded with.60 per cent. of the average breaking weight under ordinary test. Left under this load, the deflection, in every instance, slowly and steadily increased from about one inch (2.54cm.) to some considerably larger amount

at the end of the period of investigation. Fortunately, as is indicated by a comparison of these initial deflections with those observed under the same weights when testing the first set, and by their close accordance with each other, these pieces were all good samples of a good quality of yellow pine.

The increase of deflection was almost precisely the same for all for several months, a fact which is of importance, as showing not only the gradual progress and steadiness of yielding, but also that no accident produced the final rupture. Finally, after several months (about 6,000 hours; the exact time is uncertain), the piece which had at the beginning shown most pliability broke completely down. The next piece to break was that which was intermediate in stiffness between the two others; it broke at the end of about 9,000 hours — precisely one year from the date on which the load was imposed.

The last of the three pieces of this set still carried its load of 60 per cent. of the maximum under ordinary test at the last date, but it was still very slowly but unmistakably yielding, its deflection having increased nearly 0.4 inch (1.016 cm.) during the preceding five months. *It finally broke July* 31, 1881, *about* 11,100 *hours after it received its load* (15 *months*) which load was, it will be noted, but about 60 per cent. of its estimated—and probably practically correct—original breaking weight.

This very remarkable result fittingly terminated this series of tests of wood subjected to prolonged stress. An inspection of the broken bars gave no indication of reduction of strength by decay; the pieces were perfectly sound and strong, and the fractures showed excellent material.

Comparing the ultimate deflections attained by the several sets of bars, it is seen that the average under ordinary test was about 1.8 inches (4.6 cm.). Under a load 0.95 that then carried, the rods broke at a deflection of 2.4 inches (6 cm.); loaded to .80 the maximum, the deflection became, at the end, 3 inches (7.62 cm.) as a maximum, and the ultimate deflection of the most lightly loaded pieces (70 per cent. the maximum load) was something less.

The last set being compared with the first, it is seen that a load of 60 per cent., the maximum given by the usual form of test, is for such pieces unsafe, although it would seem that a slightly

smaller load might have been carried indefinitely, or until decay should weaken the timber. A factor of safety of two would possibly have permitted indefinite endurance under static load.

Taking the probable breaking load under unintermitted stress as 50 per cent., that sustained as a maximum under usual tests, and *then* applying a factor of safety of two, we obtain a safe factor, based on the ordinary test, 4.

The writer would conclude, then, that timber may be placed with the "tin-class" among metals, as exhibiting a depression of the normal series of elastic limits under prolonged stress, and that this effect is so serious in its character and so important in its effects that an extended and complete investigation of the phenomena as exhibited in timber of various sizes, and of all the kinds in use in engineering, or in construction generally, would be of great value, even if not imperatively demanded.

In brief, the conclusions to be drawn from the research here described, as having been made during the past fifteen months in the Mechanical Laboratory of the Department of Engineering of the Stevens Institute of Technology, are evidently that small sections of yellow pine timber yield steadily over long periods of time under loads exceeding 60 per cent., the maximum obtained by ordinary tests of their transverse strength, and finally break after a period, which with the lighter loads may exceed a year; that deflections half the maximum reached under test may be unsafe for long periods of time, and that a factor of safety of at least 4 should be used for permanent static loads when the character of the material is known.

The writer would, in the light of what is now known, always use a factor of safety of at least 5 under absolutely static loads, and when the uncertainties of ordinary practice as to the exact character of material, and especially where shake and the impact of live loads were to be considered, would make the factor not less than 8, and for much of our ordinary work 10.

The above experiments were arranged and supervised by Mr. J. E. Denton, and the observations made and recorded by Mr. A. Riesenberger, to both of whom the writer is under great obligations for intelligent and zealous assistance and coöperation in this as in many other investigations.

TABLE 1.

Usual method of test. Distance between supports 40 inches.

A. $b=1.113''$; $d=1.105''$. Load, lbs.	A. Deflection, inches.	B. $b=1.107''$; $d=1.107$. Load, lbs.	B. Deflection, inches.	C. $b=1.1''$; $d=1.1''$. Load, lbs.	C. Deflection, inches.
0	—	0	—	0	—
50	.2127	50	.2035	50	.2188
After 5 min.	.2164	After 5 min.	.2125	After 5 min.	.2231
100	.4339	100	.3935	100	.4528
" 5 "	.4378	" 5 "	.4000	" 5 "	.4623
150	.6575	150	.5805	150	.6833
" 5 "	.6696	" 5 "	.5835	" 5 "	.6950
200	.8984	200	.7640	200	.9298
" 5 "	.9146	" 5 "	.7730	" 5 "	.9468
250	1.1552	250	.9630	250	1.2058
" 5 "	1.2286	" 5 "	.9775	" 5 "	1.2433
300	1.5109	300	1.1805	300	1.5648
" 5 "	1.5931	" 5 "	1.2180	" 5 "	1.6713
" 6 "	1.6029	350	1.4705	" 6 "	1.6883
350	1.9329	" 5 "	1.5381	325	1.8568
380	Broke	" 6 "	1.5700	340	Splintered
.....	.....	410	Broke	345	Broke

TABLE 2.

Time test; $P=350$ lbs. Distance between supports 40 inches.

Load, lbs.	A. $b=1.1$; $d=1.1$ Time load was applied. Hours.	A. Deflection, inches.	B. $b=1.12$; $d=1.12$ Time load was applied. Hours.	B. Deflection, inches.	C. $b=1.1$; $d=1.1$ Time load was applied. Hours.	C. Deflection, inches.
40 (weight of box).						
350	....	.1565	....	.1705	....	.1840
850	....	1.7350	....	1.7175	....	2.0300
350	18	2.3385	Between 27 and 30½	Broke	¼	2.3500
350	43	Broke			Between 4½ & 13½	Broke.

TABLE 3.

Time test; $P=300$. Distance between supports 40 inches.

	A. $b=1.11$; $d=1.08$		B. $b=1.1$; $d=1.12$		C. $b=1.1$; $d=1.12$	
Load, lbs.	Time load was applied. Hours.	Deflection, inches.	Time load was applied. Hours.	Deflection, inches.	Time load was applied. Hours.	Deflection, inches.
40 (weight of box).						
300	....	.1641	....	.1470	....	.1930
300	....	1.4461	....	1.1215	....	1.6725
300	1	1.5980	½	1.1835	1	1.8660
300	3	1.6666	3	1.2370	2	1.8950
300	5	1.7316	4½	1.2735	18½	2.2150
300	22½	1.9171	5	1.2770	44	2.5450
300	47½	2.1026	21¾	1.4280	50	2.5920
300	54	2.1316	46¾	1.5185	66½	2.7310
300	70½	2.2596	69¾	1.6380	Between 79½ and 88½	3.0000
300	78½	2.4796	77¾	1.7740		broke
					....	
300	95½	2.7586	94¾	1.8505	....	....
300	118½	3.0586	117¾	1.9360	....	....
300	121	broke	141¾	1.9610	....	....
300	....	....	165¾	1.9830	....	....
300	....	....	189¾	2.0050	....	....
300	....	....	238	2.0280	....	....
300	....	....	262	2.0440	....	....
300	....	....	286	2.0580	....	....
300	....	....	310	2.0630	....	....
300	....	....	335	2.0810	....	....
300	....	....	359	2.1110	....	....
300	....	....	406	2.1310	....	....
300	....	....	430	2.2110	....	....
300	....	....	454	2.2820	....	....
300	....	....	478	2.4570	....	....
300	....	....	502	2.5510	....	....
300	....	....	526	2.5870	....	....
300	....	....	598	2.6435	....	....
300	....	....	622	2.6520	....	....
300	....	....	646	2.6600	....	....
300	....	....	619	broke.	....	....

TABLE 4.

Time test; $P=250$ lbs. Distance between supports 40 inches.

	No. 1. $b=1.08''$; $d=1.1''$.		No. 2. $b=1.08''$; $d=1.1''$.		No. 3. $b=1.1''$; $d=1.1''$.	
Load, lbs.	Time load was applied. Hours.	Deflection, inches.	Time load was applied. Hours.	Deflection, inches.	Time load was applied. Hours.	Deflection, inches.
37 (weight of box).						
250	....	.1342	....	.1532	....	.1290
250	....	1.0317	....	1.0403	....	.9821
250	91	1.2927	90	1.3757	89	1.2696
250	161½	1.3967	160½	1.5132	159½	1.3796
250	185½	1.4077	184½	1.5402	183½	1.4076
250	210½	1.4237	209½	1.5592	208½	1.4246
250	233½	1.4373	232½	1.5862	231½	1.4446
250	258½	1.4942	257½	1.6602	256½	1.5196
250	281½	1.5227	280½	1.7042	279½	1.5651
250	305½	1.5377	304½	1.7217	303½	1.5736
250	329½	1.5547	328½	1.7402	327½	1.5856
250	353½	1.5657	352½	1.7492	351½	1.6036
250	402	1.5797	401	1.7662	400	1.6216
250	426	1.5897	425	1.7762	424	1.6286
250	450	1.5957	449	1.7852	448	1.6346
250	474	1.5997	473	1.7872	472	1.6396
250	499	1.6097	498	1.8032	497	1.6506
250	523	1.6257	522	1.8132	521	1.6636
250	570	1.6617	569	1.8632	568	1.6916
250	594	1.7047	593	1.8832	592	1.7836
250	618	1.7417	617	1.9522	616	1.7646
250	642	1.7777	641	1.9982	640	1.8066
250	666	1.8187	665	2.0342	664	1.8456
250	690	1.8347	689	2.0522	688	1.8566
250	762	1.8677	761	2.0852	760	1.8868
250	786	1.8777	785	2.0932	784	1.8946
250	810	1.8827	800	2.1032	888	1.9026
250	1195	1.9832	1194	2.1822	1193	1.9906
250	2107	2.1777	2106	2.3912	2105	2.1696
250	2923	2.2757	2922	2.4917	2921	2.2676
250	6715	2.9297	6006±	broke	6713	2.6416
250	8800±	broke	....	....	....	....
250	....	....	....	....	11100±	broke±

METHOD OF DETERMINING THE VALUE OF THE SOLAR PARALLAX FROM MERIDIAN OBSERVATIONS OF MARS AT OPPOSITION. By J. R. EASTMAN, of Washington, D. C.

[ABSTRACT.[1]]

THIS method requires the observation of Mars and a previously selected list of comparison stars at a station in the northern hemisphere and at one in the southern hemisphere, on the same night.

The stars are so selected that the mean of their north-polar distances shall be approximately the same as the north-polar distance of Mars during the time the list of stars is to be observed.

The observed north-polar distance of Mars at the northern station A is compared with the mean of the north-polar distances of the stars, as a standard. A similar comparison is made at the southern station B. The observed north-polar distance of Mars at station B is then corrected by the quantity necessary to reduce the mean of the north-polar distances of stars at B to that found at station A. Then the difference between the north-polar distances of Mars at the two stations is due to the parallax of Mars.

Given the latitude of the two stations, the dimensions of the terrestrial spheroid and the geocentric distance of Mars when the sun's mean distance is taken as unity:—and a simple computation will give a value of the solar parallax for each night's work at any two stations.

Of course all these observations should be made by experienced and careful observers, and every known precaution taken to ensure accurate results.

By this method, the effect of errors in refraction due to considerable differences of zenith distance; the errors in the adopted corrections for flexure of telescope and circle; and the unknown errors in the places of the comparison stars, are all eliminated.

In the observations at Washington, Cambridge, U. S. A., Leyden, Sydney, Melbourne and Cape of Good Hope, at the time of the opposition of Mars in 1877, it was arranged to observe Mars and *eight* comparison stars (four *before* the transit of Mars and four *after*) each night at every station. The work of no night was used in the reduction of the observations at any two obser-

[1] The complete paper will be printed in the Washington Astronomical and Meteorological Observations for 1877.

vatories, unless at least the *same four* stars were observed at each station.

The value of the solar parallax found from the work at each group of stations, together with the final result, is given below.

There are also given the number of nights' observations used for each group of stations.

STATIONS.	π	NIGHTS.
Washington and Melbourne..........	8″.971 ± 0″.032	19
" " Sydney..............	8 .885 ± 0 .055	7
" " Cape of Good Hope.	8 .896 ± 0 .073	7
Melbourne and Leyden................	8 .969 ± 0 .026	27
" " Cambridge...........	9 .138 ± 0 .050	10

From all the stations, using computed weights for each night, the value of π is 8″.980.

Omitting Cambridge, which shows a systematic difference, and we have finally:—

$$\pi = 8''.953 \pm 0''.019.$$

HISTORY OF ALHAZEN'S PROBLEM. By MARCUS BAKER, of Washington, D. C.

[ABSTRACT.]

ALHAZEN'S problem is an optical one and was thus stated by the Arabian Alhazen for whom the problem is named. "*Given a luminous point and a point of vision unequally distant from the center of a convex spherical mirror, determine the point of reflexion.*"

The solution of this problem involves the solution of the following geometrical problem now generally known among mathematicians as Alhazen's Problem. *From two given points in the plane of a given circle draw lines meeting in the circumference and making equal angles with the tangent drawn at that point.*

This problem was first solved by Alhazen a learned Arabian of the eleventh century and published at Basle in Latin in 1572. Since that time it has been studied by several distinguished mathematicians and a variety of solutions given. The paper presented contained a collection of these solutions aiming to be complete. Eleven solutions were contained in this collection beginning with Alhazen and ending with a solution by E. B. Seitz in 1881.

The first five solutions are by geometrical constructions in which the points sought are determined by the intersections of a circle and hyperbola. The sixth solution, also a geometrical construction, is by means of the intersection of a circle and parabola. The seventh, eighth, ninth and eleventh solutions are by analytical or algebraical methods while the tenth is a trigonometrical solution.

Among the people who have studied and solved the problem are Alhazen, Barrow, Hutton, Huyghens, Kaestner, Leybourn, L'Hospital, Robins, Seitz, Sluse and Wales. A complete list of bibliographical references was appended to the paper. The paper contained further an extension of the problem, *first*, to the surface of a sphere and *second*, to an ellipse. The first case was illustrated by the following practical example :—

The great circle track between San Francisco, Cal., and Yokohama, Japan, reaches nearly to latitude 52° N. The Pacific mail steamers plying between these ports usually avoid going north of latitude 45° N. Now if the 45th parallel of latitude be designated as one north of which the steamer is not to go, in what longitude must this parallel be reached in order that the steamer's path between the ports shall be the shortest possible? The extension of Alhazen's Problem to the surface of a sphere solves this problem and the longitude required is 168° W. from Greenwich.

The extension of the problem to the case in which an ellipse replaces the circle gives rise to a very complex equation of no special value.

[Since this paper was read before the Association it has been remodelled and abridged, and in this remodelled form will appear in the American Journal of Mathematics, published under the auspices of the Johns Hopkins University at Baltimore, Maryland.]

On recent deep-sea soundings in the Gulf of Mexico and Caribbean Sea, by the U. S. Coast Survey. By J. E. Hilgard, of Washington, D. C.

[ABSTRACT.]

Owing to the absence of Mr. Hilgard, this paper was presented by Mr. W. H. Dall on the part of the U. S. Coast and Geodetic Survey. It consisted mainly of the exhibition of a relief model of the Gulf of Mexico and of manuscript charts from data obtained during the recent operations of the Survey in the Caribbean Sea.

The physical characteristics of both basins were thus shown and the attention of the Association was directed by Mr. Dall to the more remarkable features of the sea bottom developed by the investigations referred to.

[A detailed account of the principal results will be found in an article by Prof. Hilgard entitled "The basin of the Gulf of Mexico," printed in the American Journal of Science and Arts, vol. xxi, p. 288, April, 1881, and in the Bulletin of the Museum of Comparative Zoölogy, vol. v, No. 14, in a letter from Prof. Agassiz to the Superintendent of the U. S. C. and G. Survey.]

Comparison between the Yard and Metre by means of the Reversible Pendulum. By C. S. Peirce, of Baltimore, Md.

[ABSTRACT.]

Two reversible pendulums have been constructed, one measuring approximately a yard between the knife-edges the other a metre. These two pendulums will next winter be swung simultaneously, the metre pendulum being kept at 0° C. and the yard pendulum at 60° F. during the operation. The metre pendulum will then be compared at 0° C. with a standard metre which will be forwarded to Breteuil; and the yard pendulum will be compared at 60° F. with a standard yard which will be officially compared in England. In this manner it is expected to determine the ratio of the metre to the yard with greater exactitude than has yet been attained.

A Preliminary Investigation of the two causes of Lateral Deviation of Spherical Projectiles, Based on the Kinetic Theory of Gases. By H. T. Eddy, of Cincinnati, Ohio.

[ABSTRACT.]

THE passage of a projectile increases the density of the atmosphere in front of it but decreases that behind it. If the atmosphere had no viscosity and there was no friction, the increase of the density in front would be equal in amount to the decrease of the density in the rear; but viscosity and friction cause a current which increases in velocity and volume from front to rear, so that the decrease below the mean density is not so great in the rear of a projectile as the increase above the mean in front of it.

If now a spherical projectile have a velocity of rotation (about a vertical axis for example) as well as a horizontal velocity of translation, two causes of lateral deviation are developed: first, friction causes a deviation toward the side of the projectile possessing the greatest velocity; and secondly the unequal distribution of pressures causes a deviation toward the side having the least velocity.

Friction exerts its greatest deviating effect at high velocities of translation, but the pressures on the contrary at low velocities. From this it may readily occur that the deviation of a projectile is in the first part of its path controlled by the frictional component; while in the latter part of its flight, after a part of its initial velocity has been lost, the deviation is controlled by the pressures, thus causing a point of inflexion in the horizontal projection of its path.

Note on the Theory of the Flight of Elongated Projectiles. By H. T. Eddy, of Cincinnati, Ohio.

[ABSTRACT.]

PROFESSOR MAGNUS is the author of a piece of apparatus intended to illustrate this phenomenon. He mounted a solid in the form of an elongated projectile after the manner of a gyroscope, so that it could rotate freely about two unequal principal axes of inertia. He then directed a current of air obliquely upon the shot while in rapid rotation about its axis of figure.

This axis then suffered a continuous slow angular deviation due to the unequal pressures.

The mathematical theories of the deviation of long shot from rifled guns have been based upon this phenomenon.

Now this note points out that the effect of friction, which may often be found to be the controlling factor in the deviating force, and which is entirely neglected in this experiment, exerts a deviating force coinciding in direction with that of the pressures, and that the friction should therefore not be neglected in any complete discussion of such deviation.

On the Mechanical Principles involved in the Flight of the Boomerang. By H. T. Eddy, of Cincinnati, Ohio.

[ABSTRACT.]

The lateral deviations and wide horizontal curves described by the boomerang in its flight are shown to be due to its extended frictional surfaces, and their peculiarities of form to the wide variations in the velocity of translation, which velocity in the first part of the path decreases to nothing, is reversed in direction and then increases, while the rotary velocity steadily diminishes.

On a New Method of applying Water Power of Small Head to effect the Direct Compression of Air to any required High Pressure. By H. T. Eddy, of Cincinnati, Ohio.

[ABSTRACT.]

The author proposes to cause the water used in compressing air to pass downward from the source of supply in a pipe to such a depth that the water pressure at the lowest point shall be equal to the required air pressure, and then pass upward to the tail race, so that the pipe carrying the water is an inverted syphon. In this pipe runs an endless chain to which is attached a series of inverted buckets carrying air.

The chain and buckets are propelled through the pipe by the current of water, and the air is discharged into a receiver at the required pressure as the buckets turn over at the lowest point.

The details of construction can only be given in connection with the drawings accompanying the paper.

A NEW SELF-REGISTERING, MIRROR BAROMETER. By JOHN R. PADDOCK, of Hoboken, N. J.

[ABSTRACT.]

THE important feature in this barometer is the obtaining of a more accurate trace of the barometric variations, together with the ready indication of minute changes in this variation. The tube employed is the ordinary siphon tube with its extremities enlarged to $1\frac{1}{10}$ inches in diameter. A lever attachment is arranged as follows:

A lever of the first order is constructed with arms one inch and eight inches long respectively; the shorter arm has the form of a quadrant of a circle, and carries suspended by a platinum thread a glass jar of mercury, which is always perpendicular to the surface of the mercury in the tube.

The whole system is delicately balanced at the fulcrum upon knife edges, riding upon plates of polished steel.

This jar is filled so that the system just balances, when an additional drop of mercury is sufficient to cause it to rest upon the barometric column but in no way to visibly depress it. The longer arm of the lever carries a fluid pencil which leaves a permanent trace on paper, upon contact, little or no friction being required when once started.

The mirror attachment consists of two small plain mirrors placed upon the axis of, and at right angles to, the lever. A ray of light being directed upon either of them, it is reflected back to a scale board placed at any convenient distance, and the variations of the mercury read off by means of a spot of light in a manner similar to that of a Thompson's Reflecting Galvanometer. A change of $\frac{1}{10,000}$ of an inch in the column of mercury has been easily detected in this way, by an observer six feet from the scale board. The barometer has been in practical operation in New York city during the past winter (1880–81) and daily compared with the reports of the signal service officers, the results being invariably in close agreement when reduced.

Note on the Electrical Resistance and the Coëfficient of Expansion of Incandescent Platinum. By E. L. Nichols, of Richmond, Ky.

I.

In the measurement of temperatures above the red heat, platinum pyrometers, in one form or another, are as important as the mercury thermometer is at ordinary temperatures. The researches already completed, on the electric resistance and cöefficient of expansion of platinum, and on the specific heat of that metal, only serve, however, as a reminder of the much that remains to be done before we may hope to attain to even a fair degree of accuracy in the measurement of temperatures above 500°.

The present writer, in order to compare the existing formulæ for the temperature of platinum from its electric resistance, with those by which the temperature is calculated from the cöefficient of expansion, and thus to gain a clear idea of the relative accuracy and usefulness of the two methods, has determined the resistance and the corresponding length of a platinum wire at various temperatures between 0° and the melting point of that metal.

II.

Upon a platinum wire 0.4^{mm} in diameter and 100^{mm} long, at points 55^{mm} apart and equally distant from the middle of the wire, two very fine platinum wires were welded. They marked the ends of the portion of wire to be tested and made electrical connection with a shunt containing a galvanometer.

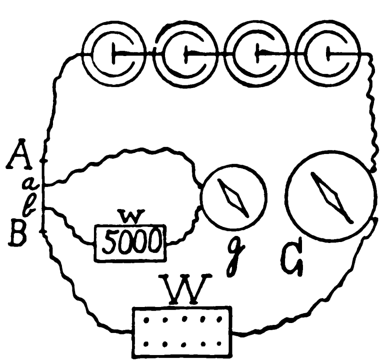


Fig. 1.

These points were so far from the ends of the wire that when it was heated by the current they were not appreciably cooled by the conduction. The wire was heated by a battery of forty Bunsen cells, and its resistance was determined by the following method.

The wire AB (see figure 1) together with a tangent galvanometer (C) and a resistance box (W) was in circuit with the Bun-

sen battery. A very small portion of the current was shunted around *ab*, the portion of the wire to be measured and carried through a sensitive sine galvanometer (g) and a resistance coil (w) containing 5,000 ohms. Now if w be very much larger than r, the resistance of the portion of wire *ab*, so that the current through *ab* is not sensibly less than that through the main circuit, we shall have

$$r = \frac{\text{tang V}}{\sin U} \cdot K;$$

where U is the deflection of the sine galvanometer (g), and V the deflection of the tangent galvanometer (*C*), and K a constant quantity.

For by Ohm's law,

$$E = cr = c'r',$$

where c and c′ are the currents through *ab* and through the shunt, and r′ is the resistance of the shunt; also

$$c' = \sin Uk';$$

and when r′ is much larger than r,

$$c = \tan Vk,$$

where k′ and k are the constants of the galvanometers.

Then

$$r = \frac{\text{tang V}}{\sin U} \frac{k}{k'} r' = \frac{\text{tang V}}{\sin U} \cdot K$$

$$\text{where} \quad K = \frac{k}{k'} r'.$$

The length of the wire *ab* was measured by bringing the two microscopes of a comparator into such position that the terminal a was in focus in the field of one of them, and b in the field of the other. Since these terminals were each rather nearer the middle than the end of the platinum wire, every change of temperature caused a movement of both a and b, and it was by taking the difference of these that the true change in the length of *ab* was determined.

As the microscopes were provided with excellent micrometer scales and screws, a fair degree of accuracy was obtained by this method: thus readings of the length of the wire at 20° agreed with those taken upon a dividing engine to within $.002^{mm}$. The distance *ab* at 20° was found to be 53.5576^{mm}.

The resistance of the cold wire was found,—in terms of U, V, and K,—by placing the wire in a naphthaline bath, and obtaining values of U and V with various amounts of current. From these readings a curve was drawn, with $\frac{\text{tang V}}{\sin U}$ as abscissæ and tang^2 V as ordinates, tang^2 V being taken as the heating effect of the

current. The point of this curve corresponding to $\tan^2 V = 0$ was taken as the proper value of $\frac{\tan g\, V}{\sin U}$ for the cold wire. When measuring the resistance of the hot wire, the galvanometers were read simultaneously before and after each determination of the length.

The following table gives the results of the measurements for temperatures ranging between 0° and a point not far below the melting point of platinum. Both resistance and length of wire at 0° are taken equal to unity.

TABLE I.

RESISTANCE.	LENGTH.	RESISTANCE.	LENGTH.
1.0000	1.00000	3.7090	1.01229
1.0410	1.00002	3.7427	1.01223
1.5071	1.00125	3.7813	1.01285
1.9000	1.00289	3.8750	1.01349
2.1212	1.00380	3.8904	1.01371
2.2934	1.00456	3.9305	1.01378
2.3035	1.00489	4.0303	1.01450
2.7821	1.00732	4.0631	1.01469
2.8633	1.00763	4.0655	1.01495
2.9696	1.00809	4.0747	1.01499
3.3533	1.01022	4.0841	1.01514
3.3741	1.01003	4.1248	1.01540
3.4151	1.01042	4.2005	1.01567
3.6449	1.01100	4.2447	1.01632

III.

Dr. Siemens has published three formulæ for the variation of the resistance of a platinum wire with the temperature. The temperatures were measured in one case (a) from the heating effect of a copper ball, the specific heat of copper being regarded as a constant, while the other two formulæ were derived from direct measurements with the air thermometer. These formulæ are,

$$(a)\quad r = .039369\ T^{\frac{1}{2}} + .00216407\ T - .24127$$
$$(b)\quad r = .0021448\ T^{\frac{1}{2}} + .0024187\ T + .30425$$
$$(c)\quad r = 092183\ T^{\frac{1}{2}} + .00007781\ T + .50196$$

where T is the absolute temperature and r the resistance.

The following formula by Benoit is also sometimes used for the determination of high temperatures.

$$(d)\quad r = 1 + .002445\, t + .000000572\, t^2.$$

In this formula t is the temperature in degrees centigrade. When, as is frequently the case, it is more convenient to measure

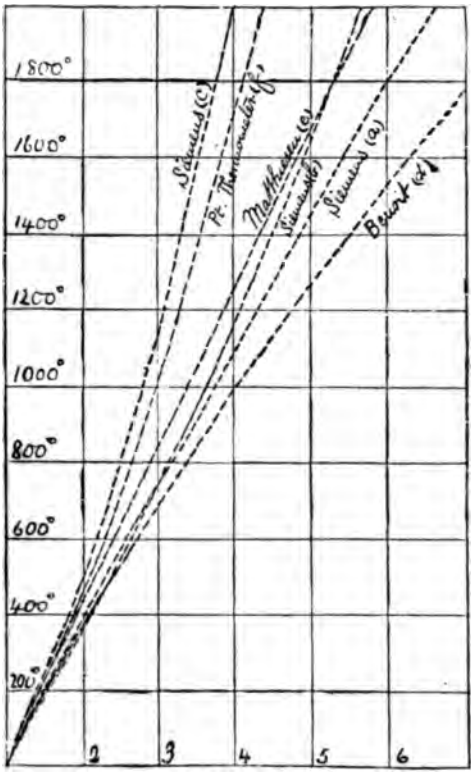


FIG. 2.

the length of a wire than its resistance, we may adopt Matthiesen's formula, viz.:

$$(e)\quad l = l_0\,(1 + .00000851\, t + .0000000035\, t^2).$$

[where l = length of wire and t = temperature]: or use the uncorrected scale of the platinum thermometer

$$(f)\quad l = l_0\,(1 + .00000886\, t).$$

These being almost the only data we possess for the calculation of the temperature of a hot wire, the question of their accuracy

is of some importance. The formulæ may be best compared by plotting, side by side, the curves which represent them (see figure 2). In the figure, resistance is substituted for length in formulæ *e* and *f* by making use of the measurements given in the second paragraph of this paper. The following table affords a further comparison of the six formulæ.

In the columns *a* to *f* are given the temperatures calculated by the various formulæ, at which the resistance of the wire, compared with its resistance at 0° as unity, is given in the column marked *r*.

TABLE II.

		SIEMENS.			BENOIT.	MATTHIESEN.	PT. THERMOM.
Length.	*r*	*a*	*b*	*c*	*d*	*e*	*f*
1.0000	1.00	0°	0°	0°	0°	0°	0°
1.0032	2.00	325°	402°	420°	378°	342°	375°
1.0082	3.00	692°	812°	1108°	708°	726°	917°
1.0146	4.00	1086°	1244°	1950°	1000°	1170°	1323°
1.0280	5.00	1464°	1682°	3170°	1272°	1638°	3100°
......	6.00	1828°	2072°	......	1512°	2158°	......
......	7.00	2170°	2387°	......	1766°	2800°	......
......	8.00	2470°	2692°	......	1978°	......	......

IV.

The curves marked Siemens *b* and *c* were identical so far as the methods employed are concerned, but the platinum used contained some slight impurities. To this the disparity of the results was due. Dr. Siemens found that even such impurities as are usually contained in commercial platinum affected both the resistance of the cold metal, and the law of the change of resistance with the temperature.

Benoit's formula (*d*) depends for its accuracy upon the determination of the boiling points of mercury, sulphur, cadmium, and zinc; for which temperatures he adopted the values given by De Ville and Troost.[1] M. Ed. Becquerel opposed those values at the time of their publication, and later researches have confirmed him, at least so far as cadmium and zinc are concerned, in think-

[1] De Ville and Troost, Annales de Chimie, Ser. 3, T. 58.

ing them entirely too high. In the following table the results of De Ville and Troost are compared with the more probable values of other physicists.

TABLE III.

METALS.	DEV. & T.	OTHER VALUES.	AUTHOR.	WHERE PUBLISHED.
Hg.	360	350	Regnault,	
S.	440	448	Bennett,	Am. Jour. Sc. 1878.
		446	Carnelly &	Journal, Chem.
Cd.	860	772	Williams,	Society, 1876 - 78.
Zn.	1040	884	Becquerel.	Comptes Rendus 57.

The substitution of these other values in Benoit's formula places it more at variance than ever with the work of Siemens and of Matthiesen; a variation probably due to the difference of behavior noticed by Siemens in the case of different specimens of platinum.

This brief discussion of the above mentioned results suffices we think to show that,

1. The formulæ are based for the most part, if even a fair degree of accuracy be claimed, upon unwarrantable assumptions, —such as the constancy of the specific heats of copper and platinum, the constancy of the coëfficient of expansion of the latter metal, and upon the accuracy of certain determinations of the boiling points of the metals Zn, Cd, etc.

2. That aside from the inaccuracy of those data, the variation of different specimens of platinum renders the use of any formula for the calculation of the temperature of the metal from its electric resistance applicable only to the individual wire for which the law of change of resistance had been determined or at best to a wire identical chemically and physically with the former.

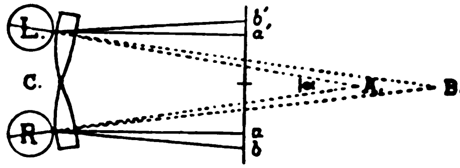
3. That from the data at command we are not in position to calculate the temperature of an incandescent platinum wire, either from its expansion or change of resistance, further than to find an expression of the temperature in terms of the length or of the resistance of the wire.

4. That owing to the great variations shown by different specimens of platinum as regards resistance, the determination of the expansion is to be preferred whenever practicable to the measurement of the conductivity.

THE STEREOSCOPE, AND VISION BY OPTIC DIVERGENCE.

By W. LECONTE STEVENS, of New York, N. Y.

[ABSTRACT.[1]]



LET a and a' be corresponding foreground points, b and b' corresponding background points on a stereograph card, symmetrically situated with regard to a median line from C to B. Rays from a and a' are deviated by lenticular prisms into the eyes, R and L, as if they came from A; likewise b and b', as if from B.

Let $i =$ RL $=$ distance between optic centres.

Let D $=$ CA $=$ apparent distance of point of sight,

Then, $$D = \tfrac{1}{2}\, i \text{ Cot } \tfrac{1}{2}\, a.$$

Suppose prisms and stereograph removed and a binocular camera substituted.

Let $i =$ RL $=$ distance between two cameras.

Let D $=$ CA $=$ distance of point to which they are directed.

The formula then gives the absolute distance of the object photographed.

If $a = 0$, $D = \infty$; if $a < 0$, $D < 0$.

Both these conditions imply that there is no point of sight at any finite distance in front. Hence, if distinct vision in the stereoscope is possible when the visual axes are parallel or divergent, the mathematical theory of the stereoscope, as usually accepted and taught, is incorrect.

To test this, measurements of the foreground interval, aa', were made on 166 stereographs. It was found to vary between 60^{mm} and 95^{mm}, the mean being 72.9^{mm}. The mean interocular distance, i, for adults, is about 64^{mm}. Hence, if the rays, aR and a' L, enter the eyes without transmission through prisms, and binocular fusion of retinal images is attained, this shows that axial divergence also is attained, if we assume average stereographs

[1] Printed in full in Am. Jour. Sci., Nov. and Dec., 1881; also in Transactions of N. Y. Academy of Sciences, Nov. and Dec., 1881, and abstract in London Philosophical Magazine, Dec., 1881.

and average separation between the eyes. My own eyes, though perfectly normal, have been thus diverged 7°, an extent that is easily noticeable. Many other persons have been found to possess the same power in less degree.

To ascertain whether divergence is unconsciously practised in using the stereoscope, thirty pairs of lenticular prisms were examined. The mean focal length was 18.3^{cm}. Parallel rays, 64^{mm} apart, were transmitted at points opposite R and L, the screen being 18.3^{cm} distant. The mean interval between points of light caught on the screen was found to be 79.12^{mm}. Hence, if the stereographic interval aa′ exceed 79.12^{mm}, optic divergence is necessary, assuming the average stereoscope and average interocular distance. This interval is not infrequently exceeded, though it is greater than the average stereographic interval, 72.9^{mm}. It was found that the mean value of the angle, a, on the assumptions just made, was 1° 57′, which corresponds to 1.88^{mm} as the distance of the point of sight.

A variety of elements are to be considered in estimating the distance of an object of sight. The relation between the visual axes, being only one of these, is not alone sufficient. Its value depends largely upon our recognition of the degree of muscular strain induced in rotating the eyeballs. Rotation inward is habitually associated with approach of the object of sight, rotation outward with its recession. In like manner, contraction of the ciliary muscle is associated with nearness, relaxation with remoteness, of the object to which the focal adjustment has to be adapted. Axial adjustment and focal adjustment are consensually adapted to the same point of sight in normal binocular vision and conduce to the same judgment of distance, which increases in accuracy as the object is nearer. The value of each is greatest near the minimum limit of distinct vision, which is also about the distance at which stereographs are usually held when regarded. At this distance, 25^{cm} in normal vision, the optic angle, a, is about 15°.

In average vision through the stereoscope, since a is about 2°, while the apparent distance of the card, as magnified by the lens, is less than 25^{cm}, the focal and axial adjustments are not consensually accordant, and the judgment of distance is vitiated by this conflict between important elements which thus tend to produce widely different impressions. The discordance increases as

the stereographic interval is greater. The outward rotation of the eyeballs ceases to give any definite impression in regard to absolute distance after the limit of optic parallelism is passed, but it still produces the illusion of recession of the object of sight, which continues to appear in front even though the intersection of axes be in the rear.

The axial and focal adjustments may be called physiological elements of perspective. Other elements such as variation of visual angle, of light and shade, the partial covering of remote objects by near ones, parallax of motion, etc., may together be called physical elements. All of the latter, except parallax of motion, may be imitated in pictures and are usually present in stereographs. Whatever be the object viewed moreover, we compare it with realities to which it bears some recognizable relation. Thus a chain of mountains and a diagram of a single crystal will never be judged equally distant, even though physiological perspective be the same for both pictures. This element of comparison may be included in physical perspective.

We may conclude that in vision through the stereoscope our judgment of distance is determined principally by physical perspective. To this must be added the element of axial convergence for the two cameras when the pictures are taken, in consequence of which these are slightly dissimilar. The relation between the different parts of each picture remains fixed whether the direction of the eye that views it be perpendicular or slightly inclined to the plane of the card. If the retinal images of them be superposed in the binocular eye[2] the relation between the visual axes must be varied slightly in securing distinct vision of the foreground and background successively, and the illusion of stereoscopic relief is a consequence of this duplication, however slight, of the images of one part of the picture while the rest is seen singly and distinctly. But in the production of this axial variation, if the eyes are comfortable, it makes but little sensible difference whether the visual axes are, at a given moment, convergent, parallel, or divergent.

If they be more convergent than were the camera axes when the picture was taken, the object appears nearer, smaller, and with diminished perspective. If they be divergent, it appears farther, larger, and with exaggerated perspective. This is best studied with the aid of Wheatstone's reflecting stereoscope.

[2] See Amer. Jour. Sc., Series III, vol. I, p. 33, et seq.

The theory of binocular perspective based exclusively on convergence of visual lines was elaborated by Wheatstone, and, more especially, by Brewster. It has reappeared, in the explanation of the stereoscope, in every text-book of Physics to which I have referred. At best it is only an approximation to the truth in special cases. It ignores important physiological conditions, is totally inapplicable in a very large number of cases, is misleading to the student, and should never be taught except in connection with the physiological conditions which are always present, and which destroy its mathematical value. It is nevertheless strictly applicable to the binocular camera.

An Improved Sonometer. By W. LeConte Stevens, of New York, N. Y.

[ABSTRACT.]

The following are the principal features:

I. The resonance-box is an open organ pipe whose length is so adjusted that the enclosed column of air responds to C (132 vibrations per second) as fundamental note. One side of the pipe is made of thin spruce, upon which the two fixed bridges are fastened, one metre apart.

II. In contact with the spruce sounding-board is a thin strip of wood, on which are marked the following, for the assistance of the operator in using the movable bridges:

1. On one edge, a millimetre scale.

2. On the other edge, division marks at which the movable bridge may be placed to obtain the notes of four successive octaves of the natural scale, including minor semitones for the first and second octaves; also division marks for obtaining the first twelve notes of the harmonic series.

3. Along the middle, division marks for obtaining the first and second octaves of the scale of equal temperament.

III. A series of separate short strips to slide along the edge of the long strip next the millimetre scale. Each is provided with

division marks, beginning with a selected key-note of the natural scale, so as to give the cord lengths for each note in its own natural gamut. When adjusted in position, a comparison of its division marks with those of the tempered scale gives the error of the latter, which may be made perceptible to both eye and ear.

IV. The embouchure of the organ pipe may be varied in size with a sliding plate. By adjusting this and varying the blast, twelve harmonics in succession may be obtained, the purity of which may be tested by comparison with corresponding harmonics obtained from the stretched wires.

V. On one wall of the pipe are three funnel-shaped openings covered with sheet-rubber. The position of nodal points in the air column is shown, by conveying waves from the vibrating rubber to a manometric flame.

VI. A simple device in connection with the latter enables the operator to show the composite character of various notes from the pipe, or any other source, by interference of waves.

THE MAGNETIC SURVEY OF MISSOURI. By FRANCIS E. NIPHER, of St. Louis, Mo.

THE work done by the survey party, during the summer of 1881, has brought to light a few facts which bear somewhat upon the idea suggested at the Boston meeting, and in various prior publications, viz., the influence of earth currents upon the magnetic needle. During the present summer, particular attention has been given to the north slope of what is called the Ozark mountains. We have travelled by wagon to points where work was most needed to bring out the facts, and the stations have been from five to thirty miles apart. A star observation and a check determination of the magnetic meridian has been made at every camp, even when it was not necessary to occupy the point as a regular station. As was

anticipated, the results of the present summer have modified the isogonic lines somewhat. The Ozark mountains in Missouri consist of a high area between the upper White, the Osage, Missouri and Mississippi rivers, and the swamps of southeast Missouri. The surface is very uneven and is traversed by numberless deep crooked and narrow valleys. The average elevation above St. Louis is 400 to 500 feet, the central part of the area reaching 1200 feet.

Assuming the existence of earth currents, capable of affecting the needle, it is clear that the varying conducting power of the soil, over and around such an elevated area, would cause the stream lines to deflect around the poorly conducting centre. The effect on the needle would be to cause abnormal easterly deviation in the N. E. and the S. W. quadrants, and a westerly deviation in the N. W. and the S. E. quadrants. In the first case we should have a maximum of easterly declination, in the second a minimum. On the N. and S. and the E. and W. lines running through the centre of the area, the declination would have a normal value.[1]

For a long time the displacement to the N. W., of the closed isogonic lines around the central high area, was a source of great anxiety. The explanation of this is however very simple, and arises from the fact that the normal declination of the needle increases to the West, and the abnormal westerly deviation in the N. W. quadrant causes the declination there to approximate the normal value at the summit of the high area.

So far the facts brought out during four years of work are wholly in harmony with the hypothesis suggested.

Of course a direct *attraction* of the raised area for the *nearest* pole of the needle would produce the same effect, but this explanation is hardly deemed admissible.[2]

It is the intention to continue the survey during the next two years at least, the funds necessary having been already provided.

[1] The directions N. S. E. W. above refer to the normal magnetic meridian.

[2] The facts thus far brought out were represented by a sketch on the blackboard.

RINGING FENCES. By S. W. ROBINSON, of Columbus, Ohio.

THIS sketch is mainly of a simple fact of observation. My attention was one day suddenly arrested while walking on a hard sidewalk alongsidè a picket fence, by the peculiarity of the sound which reached my ear immediately following each step. This sound was first noticed to be very different from that perceived at other parts of the sidewalk. On instituting an inquiry for the cause of this difference, the only one discoverable was a change in the construction of the yard fences along the sidewalk.

The peculiarity observed in change of sound was very marked when passing from a portion of sidewalk opposite a board fence, to parts opposite a picket fence. In the former position a quick drop of the foot upon the walk was accompanied by a simple sound or noise of short duration. But when opposite the picket fence the noise following each footstep was prolonged into a curious musical tone of initial high, but rapidly lowering, pitch and with a duration of perhaps a quarter of a second.

This singular musical tone following, and due to, the noise of a simple footstep, could only be accounted for on the supposition that each picket of the fence reflected the sound reaching it from the foot, the rapid succession of which, from the several pickets of the fence, resulted in the sound observed.

The duration of the sound reflected from the pickets at each step is evidently due to the different distances of the pickets from the ear of the observer, and the greater length of time required for the sound to travel to and from the more distant pickets. For instance, suppose the observer is walking along a stone or mastic walk at a distance of eight feet from the fence, the latter extending either way some distance along the street. The sharp noise of the footstep returns from the nearest pickets first. Here the difference in distance from the adjacent pickets is slight, and hence the succession of reflected noises is rapid. But from more remote pickets the difference of distance is greater and the succession in reflection less rapid.

In studying the nature of the resulting tone it is at once seen that the initial pitch is due to an almost infinite number of reflections or vibrations per second, while at the end of a quarter, or half second the lines of advance and return of the sound are nearly parallel to the fence, and hence the pulsations have an in-

terval of time equal to twice the constant distance between pickets divided by the velocity of sound. For instance, if the pickets be four inches apart, or one-third of a foot, the terminal pitch would be one of about 1500 vibrations per second.

The law of retrogression of pitch may be of interest. To express it as a function of passing time, let

d = distance from observer to fence.

a = constant distance between pickets.

v = velocity of sound.

n = number of vibrations per second.

t = the time following the initiation of the reflected tone.

Then by aid of a diagram we easily obtain the following relation between the above quantities, viz.:

$$\frac{v^2}{4a^2 n^2} = 1 - \frac{d^2}{(vt + d)^2}$$

The curve for this equation is not easily classified. But by computing quantities and constructing a curve it is found to be very much like a hyperbola referred to its asymptotes, which indicates that the pitch falls rapidly at first, and less so subsequently.

Not only is the above described phenomenal reflection observed in connection with fences, but from any series of flat surfaces in steps as indeed in the case of stairs under proper conditions. Such echoes have been observed from the steps in front of the State House at Columbus, Ohio.

Four years' observations with a Lysimeter, at South Framingham, Mass. By E. Lewis Sturtevant, of South Framingham, Mass.

The Lysimeter used was a chestnut frame, strongly put together so as to enclose an area of exactly five-thousandths of an acre. The lower border was furnished with a cutting edge of iron, and by careful manipulation the frame was forced into the soil, to a depth of twenty-five inches, so as not to disturb the enclosed soil. On the upper edge a zinc edging which precisely marked out the area was then put in place. Underneath a bottom was driven; aprons were then placed on the outside of the frame to intercept all water, and to convey it to a level lower than this bottom, finally, a zinc pan was closely affixed to the bottom to catch all the filtration or drip from the area within the box.

The apparatus was completed Nov. 19, 1875, and up to January 1, 1880, careful record was made of all the water of filtration. The record of rainfall is that by the Boston Water Works, by whom a station was maintained in close vicinity.

Under the head of evaporation, I include the difference between rainfall and percolation.

The soil, a sandy or gravel loam, in poor agricultural condition, and covered with a sod which had not been disturbed certainly for ten, probably not for fifteen or twenty years. Agriculturally speaking, such a sod would produce a short half ton of hay per acre in a favorable season. Under the eight or ten inches of black loam, a yellow loam. The bottom represents the level of the gravel bed underlying the adjoining soil.

		Rainfall. Inches.	Percolation. Inches.	Evaporation. Per cent.
January, February, March, April	1876	16.61	2.546	84.7
	1877	14.90	3.557	76.1
	1878	20.49	3.882	81.0
	1879	15.37	1.087	92.9
	Average	16.84	2.768	83.5
May, June, July, August	1876	12.63	0.611	95.1
	1877	13.00	0.685	94.7
	1878	15.00	0.547	96.3
	1879	14.48	0.515	96.5
	Average	13.77	0.589	95.7
Sept., Oct., Nov., Dec.	1876	14.64	1.606	89.0
	1877	15.32	7.203	52.9
	1878	18.87	4.798	74.5
	1879	9.98	0.000	100.0
	Average	14.70	3.401	76.8
For the twelve months	1876	43.88	4.763	89.15
	1877	43.22	11.445	73.52
	1878	54.36	9.227	83.03
	1879	39.83	1.602	95.98
	Average	45.34	6.759	85.1

From these figures we may assume that, for this region, percolation is practically *nil* during the growing season, and that leaching, so much dreaded by the farmer, is, under farm conditions, not to be practically feared.

The following is the record by months:

	RAINFALL: INCHES.				PERCOLATION: INCHES.			
	1876	1877	1878	1879	1876	1877	1878	1879
January	1.54	3.01	6.06	2.56	.167	.000	.060	.000
February....	4.06	0.26	4.56	3.76	.633	.000	.090	.000
March........	7.09	8.19	4.46	4.47	.712	1.932	1.473	.281
April........	3.92	3.44	5.41	4.58	1.034	1.625	2.257	.806
May...........	2.65	3.94	0.92	1.46	.586	.646	.433	.013
June.........	1.32	3.05	3.79	3.25	.000	.039	.500	.000
July	7.19	2.67	3.14	3.61	.000	.000	.000	.000
August......	1.46	3.34	7.15	6.16	.025	.000	.114	.502
September...	4.01	0.34	1.00	1.68	.034	.000	.000	.000
October......	2.32	7.94	5.27	0.86	.000	2.060	.772	.000
November...	5.53	6.12	6.33	2.61	1.572	2.990	2.744	.000
December...	2.77	0.92	6.27	4.83	.000	1.553	1.282	.000
Total....	43.88	43.22	54.36	39.83	4.764	11.445	9.227	1.602

Not being willing to trust a wooden frame any longer, the records were discontinued with 1880, although at this time careful examination showed the apparatus to be in good order.

A REMARKABLE CASE OF RETENTION OF HEAT BY THE EARTH. By H. C. HOVEY, of New Haven, Conn.

[ABSTRACT.]

THERE is an area of about two acres, in Pictou county, Nova Scotia, where the snow never lies long without melting, and the frost, even in severe winters, penetrates but for a short distance. Over it are scattered fused masses of ironstone, resting on the outcrops of what are known as the "Main" and the "Deep" seams of bituminous coal (here about 450 feet apart), and partly on the outcrops of other smaller seams.

The name "Pictou" is from a Micmac word, signifying *fire;*

and Indian tradition still points to this spot as having once been the scene of a long-continued fire, which made the aborigines avoid the place as visited by the anger of the gods.

The coal-measures of Pictou were discovered in 1798, at the very point now described; and the place was then covered with a bed of ashes, over which grew large hemlock trees. One of these was cut down twenty years ago, and showed 230 rings of annual growth. Three feet under the root was found a piece of wood fashioned by some kind of axe.

Last spring, Mr. Hudson, manager of the Albion mines, found it necessary to sink a pit on this area, at the outcrop of the Deep Seam, to facilitate ventilation. The heat of the ashes, thirty feet below the surface, was immediately tested by a reliable thermometer and was found to be 80 degrees Fah., at a time when the surface temperature varied from a minimum of 45 degrees to a maximum of 65 degrees. Soon after an opening had been made, the air currents caused the temperature to fall to the normal point.

Mr. Edward Gilpin, Government Inspector of Mines, examined this pit, and kindly placed at my disposal the foregoing facts, together with a comparative view of sections of the same strata, made only a short distance apart; the design being to exhibit the changes made by igneous action.

The *present section* is taken at the new pit on the burnt area; and the *original section* is from the Geological Survey of Canada for the year 1869, p. 69.

Present Section.

	ft.	in.
Surface of burned clay	22	0
Band of hard scoriæ	4	0
Reddish ashes	3	0
Hardened shale	2	0
Good coal, etc. (being upper part of the Deep Seam)		+
Depth of pit	32	+

Original Section.

	ft.	in.
Black, argillaceous shale, with bands of ironstone 1 to 2 inches thick. Total thickness, 144 ft. 6 in.	2	6
Brown carbonaceous shale	1	10
Bad coal	0	2
Good coal	3	7
Black shale with ironstone bands	1	2
Good and coarse coal in alternate strata	18	1
Total thickness of Deep Seam	22	10

The surface cover of clay is changed to a reddish, coherent mass. The small portion of the 144 feet of black shale, passed through by the shaft, is transformed to hard scoriæ. The upper part of the Deep Seam of coal is completely burned away, leaving a compact, laminated, reddish ash; and in this ancient bank of ashes, known to be over 300 years old, the retention of heat was observed which it is my object now to put on record.

TIME SERVICE OF CARLETON COLLEGE OBSERVATORY. By WM. W. PAYNE, of Northfield, Minnesota.

THE purpose of my remarks is not to bring before the Association anything that is particularly new to science in principle, but rather, at the solicitation of friends, to place on record that which is being done in the way of time service in the new field of the northwest. As prefatory to this, please indulge me in a very brief statement respecting the location and instrumental equipment of the College Observatory.

The Observatory of Carleton College is located at Northfield, Minn., forty miles south of St. Paul, on one of the main lines of the Chicago, Milwaukee and St. Paul railway. The building was erected in 1878. Its latitude was determined by Prof. B. F. Thomas (now of the University of Missouri), in 1879, by a series of observations made with a two-inch Wurdemann zenith telescope, loaned to the Observatory for that purpose, by Lieut. Edw. Maguier, Chief Engineer of the Dept. of Dakota. By using the Talcott method, Professor Thomas found the latitude of the Observatory to be 44° 27′ 41″ ±. During August 1880, the work was done a second time by myself using the same instrument and method, observing forty pairs of stars, on different nights, with mean places from Safford's catalogue. After the proper reduction the latitude was found to be 44° 27′ 40″.8. These two determinations of the latitude, being a year apart in time, and wholly independent of each other were in surprisingly close agreement. In Oct. 1880, by the aid and courtesy of the officer last named and Lieut. O. B. Wheeler, of the Lake Survey, the longitude of the Observatory was determined, the Coast Survey meridian of St. Paul being used as the base of operation. Observations were taken at Northfield and St. Paul on succeeding nights, and telegraphic signals were exchanged. Independent reductions of these observations showed the longitude of the Observatory to be 1 h. 4 m. 23^s.8 west of Washington, and 14^s.3 west of the meridian of St. Paul.

INSTRUMENTS.

The Observatory is furnished with the following instruments:—

A Clark equatorial, 8¼ inch aperture, 10½ ft. focal length with complete mounting.

A Byrne equatorial, 4.3 inch aperture with portable mounting.

A Transit, made by Fauth & Co., Washington, 3 inch aperture and 42 inches focal length, with reversing apparatus. Two Howard clocks, with electric and magnetic attachments for regulating and distributing time. A Bond siderial chronometer with break-circuit attachment and an ordinary Clark chronograph.

TIME SERVICE.

The time service of the Observatory began Oct. 23, 1878, immediately after the new clocks were regulated, the Northwestern Telegraph Company (now Western Union) having previously asked for the time, and having run a telegraph line to the Observatory and furnished it with an office.

The daily electrical time-signals are given by the mean-time clock itself, which has a break-circuit attachment operated by a small wheel on the shaft of the seconds hand which has thirty-one teeth spaced to represent two seconds of time except *three*, which give continuous seconds, to mark the close of each minute. This clock is placed in a local circuit with appliances for cutting it into the main telegraph line for daily noon signals.

By arrangement with the railroad companies our mean-time clock is put into line daily at eleven o'clock and 57 minutes, so that *three* full minute signals may be given, the last stroke of the third minute being understood to mark the time of twelve exactly. Until quite recently the distribution of the time to the railroads has been effected in the following manner:—

The principal offices of resort of the companies terminating lines in St. Paul and Minneapolis have wire connection with the main office of the C. M. & St. Paul Railway for the purpose of time. In this way the Observatory clock has daily given its three-minute signals over the main lines of these companies. The branch lines use the same time, but it is repeated over them by hand. When the main lines are thus connected the clock has given its break-circuit signals over 1285 miles of wire in six different states and territories, ranging from Kansas City to St. Paul, Winona and McGregor of Iowa. For a few weeks recently, the signal has been modified by reversing the points of the relay in the local circuit, for the purpose of a *make-circuit* signal on the main lines. A five-minute signal attachment has also been applied

to the clock that time balls may be dropped, at noon, daily in connection with the railroad time service. (Arrangements are already made to drop a time-ball in each of the cities of St. Paul and Minneapolis, the apparatus for the same now being in hand.) This five-minute attachment, as it is called, is a plain disk, connected with the train of the clock so as to revolve once in five minutes, and a portion of the circumference representing fourteen seconds is cut away. It is, of course, in the local clock-circuit and serves to keep that circuit closed, and hence the main line open during the fourteen seconds preceding the *sixtieth one* before noon. This interval of open line gives opportunity to connect time-balls with electrical apparatus for dropping the same by the single noon stroke from the clock. The dropping apparatus that I use for these balls is manufactured by Prof. H. S. Pritchett of St. Louis. It is simple, neat, and effective.

DISTRIBUTION OF THE TIME.

The following railroad companies take the Northfield meridian time directly or indirectly, and use it over their lines without local change:

1. C. M. & St. Paul Ry., on its five divisions west of the Mississippi river, embracing an aggregate length of	2271
2. W. & St. Peter Ry. (branch of the C. & N. W. Ry.) uses both Northfield & Baraboo signals but runs on Northfield time	484
3. C. St. P. M. & O. Ry., from Sioux City to Elroy, Wis., on all its branches.	963
4. M. & St. Louis Ry., from Minneapolis South	260
5. Northern Pacific to end of track west in Montana	680
6. St. P. M. & M. Ry., to Winnipeg possibly, to St. Vincent certainly	680
7. St. Paul & Duluth to the head of Lake Superior	153
Total number of miles	5541

The last two companies named do not take time directly from the Observatory but from jewellers in the city of St. Paul, who receive our daily signals. It will be seen readily by inspecting the blackboard sketch, that the territory traversed by these great railroads embraces all of Minnesota, and parts of Iowa, Nebraska, Dakota, Wisconsin, Montana and possibly the province of Manitoba.

On the methods of determining the Solar Parallax, with special reference to the coming Transit of Venus. By Wm. Harkness, of Washington, D. C.

[ABSTRACT.]

The object of this paper was to compare the various methods of determining the solar parallax, and to show that the photographic method employed by the United States transit of Venus parties in 1874 is among the most accurate known, and should not be neglected in observing the transit of 1882.

Every known method of determining the solar parallax belongs to one or other of the following classes, namely:

I. Trigonometrical Methods.
II. Gravitational Methods.
III. Photo-tachymetrical Methods.

These methods were considered in detail, and the limiting values of the solar parallax given by them are appended. It should be remarked, however, that in selecting these values the results of all discussions made prior to 1857 have been omitted; except in the case of the transit of 1761, and the smaller of the two values from the transit of 1769.

I.—Trigonometrical Methods.	
Mars, meridian observations..........	8''.84 to 8''.96
" diurnal observations...........	8.60 " 8.79
Asteroids..............................	8.76 " 8.88
Transit of Venus, 1761................	8.49 " 10.10
" " " 1769................	8.55 " 8.91
" " " 1874................	8.76 " 8.85
II.—Gravitational Methods.	
Mass of the Earth.....................	8''.87 ± 0''.07
Moon's Parallactic Inequality.........	8.78 to 8.91
Earth's Lunar Inequality.............	8.66 " 9.07
III.—Photo-tachymetrical methods.	
Velocity of Light and Light Equation	8''.72 to 8''.89
Velocity of Light and Aberration... .	8.73 " 8.90

No attempt was made to obtain a definitive value of the solar parallax, because it is quite evident that by adopting suitable weights for the various data employed, almost any value from 8″.8 to 8″.9 could be got; and no matter what the result actually was, it would always be open to a suspicion of having been cooked in the weighting. We only know that the parallax seems to lie between 8″.75 and 8″.90, and is probably about 8″.85. All the methods give a probable error not far from ± 0″.06, and no one of them seems to possess decided superiority over the others.

In the beginning of the eighteenth century the uncertainty of the solar parallax was fully two seconds; now it is only about 0″.15. To narrow it still further, we require a better knowledge of the masses of the earth and moon, of the moon's parallactic inequality, of the lunar equation of the earth, of the constants of aberration and nutation, of the velocity of light, and of the light equation. All these investigations can be carried on at any time, but there are others equally important which can only be prosecuted when the planets come into the requisite positions. Among the latter are observations of Mars when at its least distance from the earth, and transits of Venus.

In 1874 all astronomers hoped and believed that the transit of Venus, which occurred in December of that year, would give the solar parallax within 0″.01. These hopes were doomed to disappointment, and now, when we are approaching the second transit of the pair, there is less enthusiasm than there was eight years ago. Nevertheless, the astronomers of the twentieth century will not hold us guiltless if we neglect in any respect the transit of 1882. Observations of contacts will doubtless be made in abundance, but our efforts should not cease with them. The probable error of a contact observation is ± 0″.15. There may always be a doubt as to the phase observed, and a passing cloud may cause the loss of the transit. On the other hand, the photographic method employed by the United States transit of Venus parties in 1874 cannot be defeated by passing clouds, is not liable to any uncertainty of interpretation, seems to be free from systematic errors, and is so accurate that the result from a single negative has a probable error of only ± 0″.55. If the sun is visible for so much as fifteen minutes during the whole transit, thirty-two negatives can be taken, and they will give as accurate a result as the observation of both internal contacts. In view of these facts, can

it be doubted that the photographic method offers as much accuracy as the contact method, and many more chances of success?

The transit of 1882 will not settle the value of the solar parallax, but it will contribute to that result, directly as a trigonometrical method, and indirectly through the gravitational methods with which the final solution of the problem must rest. As our knowledge of the earth's mass may be made to depend upon quantities which continually increase with the time, it will ultimately attain great exactness, and then the solar parallax will be known with the same exactness.

On a simple method of Measuring Faint Spectra. By Wm. Harkness, of Washington, D. C.

[ABSTRACT.]

An ordinary spectroscope, having a sixty degree prism of dense flint glass, a telescope and slit-collimator of about six and a half inches focus and seven-eighths of an inch clear aperture, and a photographed scale with its accompanying collimator, is sufficiently powerful for the common requirements of chemistry, physics, and astronomy. Such an instrument has only one inconvenience, and that is the impossibility of measuring faint spectra with the photographed scale. After numerous trials, I have hit upon a method of overcoming this difficulty, which is so simple that I can scarcely believe it is new. A screw with a sharp point, and rather a fine thread, is inserted in the tube of the viewing-telescope in such a position that the point of the screw is visible at the focus of the eye-piece. In applying this to faint spectra, the point of the screw is brought up to the line to be measured while the field is perfectly dark, and then the photographed scale is illuminated and the position of the point of the screw read upon it.

Experiments to determine the Comparative Strength of Globes and Cylinders of the same diameter and thickness of sides (with specimens of each). By Samuel Marsden, of St. Louis, Mo.

[ABSTRACT.]

For the above purpose, I had patterns and core boxes made suitable for moulding globes and cylinders four inches internal diameter and ¼ inch thickness of sides. The cylinders were made with globular ends, eleven inches in total length. For the purpose of enabling the moulder to place the core as near the centre of the mould as possible, short pipes were cast to opposite ends of both cylinders and globes, their centres coinciding with the axis of the cylinders and poles of the globes. Through these pipes the cores were extracted; afterwards a pipe belonging to each was filled with solder, and to the pipe, on the opposite end, a small piece of gas pipe was attached with a plumber joint so as to form a connection with an hydraulic testing machine. From the same pots of melted lead there were cast four cylinders and four globes, and a number of specimens ⅝ × $\frac{5}{16}$ in the centre, 1 inch × $\frac{5}{16}$ at each end and 3 inches long, for the purpose of ascertaining the tensile strength of the metal of which the globes and cylinders were composed. Finally four of these pieces were reduced with a file to ¼ × ½ inch in the middle. The upper ends were secured to a trestle the lower to a scale and weighted until torn asunder, breaking with 303½ lbs., after being subject to that weight less than one minute each, showing a remarkable uniformity of strength in the lead.

The strength of a cylinder being as its diameter and tensile strength of its sides. Let t represent the tensile strength of 1 inch long on one side, $t\,2$ will represent the tensile strength of 1 inch long on each opposite side of the diameter, D the diameter in inches, P the bursting pressure.

For a general formula we have $\frac{t2}{D} = P$. Substituting their values, in the present case we have by experiment 303½ lbs. the tensile strength of ½ inch long. Hence $\frac{t2}{D} = \frac{1214}{4}$ lbs. $= P$ 303½ lbs. as the theoretic bursting pressure of our cylinders, and twice this amount for the bursting pressure of our globes. Ex-

perimentally we find them to burst with the amounts tabulated below.

No. of cylinder.	Ex-panded to	Pressure burst with	Center of rupture from end.	Length of rupture
1	5 inches	250 lbs.	$6\frac{3}{8}$ inches	$3\frac{3}{4}$ inches
2	5 "	275 "	$5\frac{1}{2}$ "	4 "
3	$5\frac{1}{4}$ "	300 "	5 "	$4\frac{1}{2}$ "
4	$4\frac{3}{4}$ "	260 "	Defective rupture at one end.	
No. of globe				
1	$4\frac{11}{16}$ "	475 "	Rupture $1\frac{1}{2}$ from inlet.	
2	$4\frac{11}{16}$ "	500 "	" near centre on one side.	
3	$4\frac{11}{16}$ "	475 "	" 1 inch from upper pole.	
4	$4\frac{11}{16}$ "	460 "	" 2 inches from upper pole.	

In only one instance out of eight, do we find the actual strength to coincide nearly with the theoretical. The discrepancies are due to imperfections in the manufacture of the globes and cylinders. The patterns and core boxes appear to have been as near perfection as can be desired. The placing of the core in the centre of the mould and retaining it there while the metal is run is almost impossible. In view of the above facts it is folly to assume that a given globe or cylinder will stand practically the amount of pressure indicated by theory even if the material from which they are made be of a uniform tensile strength.

Historic notes on Cosmic Physiology. By T. Sterry Hunt, of Montreal.

[ABSTRACT.]

The author began by insisting that general physiology, as the philosophy of material nature, is co-extensive with general physiography, in which sense it was employed by the best writers up to the first years of this century. In the abridgments of the Philosophical Transactions of the Royal Society up to 1700 and 1720,

the chief division is into Mathematical and Physiological subjects, the latter including the phenomena of the three kingdoms of nature. There is a physiology not only of animals and plants, but of the inorganic world, and from terrestrial physiology we rise to a conception of the physiology of the Cosmos or material universe, a subject which from the earliest times has attracted the attention of philosophers. One of the most evident of the problems thus presented is that of interstellar space and its relations to our earth and its gaseous envelope. After noticing the views of the ancient Greeks, the author referred to the discovery by Alhazen of the refraction of light, from the phenomena of which the Arab philosopher attempted to fix the limit of the terrestrial atmosphere. He then noticed the similar attempts of later observers, and adverted to the well-known hypothesis of Wollaston, who endeavored to assign thereto an absolute limit on grounds which are inadmissible. He adverted to various views as to the so-called ether of space, which Newton thought must include exhalations from celestial bodies, and noticed the hypothesis of Grove, that the medium for the transmission of radiant energy through space is but a more attenuated form of the matter which constitutes the gaseous envelopes of the earth and other celestial bodies, between which, through this medium, Grove, like Newton, supposed material interchanges to take place. The suggestion of Arago as to the possibility of determining the density of the rare matter of interstellar space was noticed, as well as that of Sir William Thomson, who has even attempted to fix the minimum density of the luminiferous medium, which he, like Grove, conceives may be a rarified extension of the terrestrial atmosphere. W. Mattieu Williams, adopting the hypothesis of the atmospheric nature of the interstellary matter, has attempted to show how the sun in its course through space may condense this matter with the evolution of heat, and thus replenish the solar fires. From this ether also, by a stoichiogenic process, the various chemical species are perhaps generated.

The author has endeavored to approach the study of interstellary matter from a wholly different side. From a consideration of the chemical and geological changes of which we have evidence in the earth's crust since the beginning of life on the planet, it is clear that great quantities of carbonic dioxide have become fixed, partly in the form of carbon, with evolution of oxygen, and partly

as carbonates—equal in the aggregate to 200 atmospheres or m(This enormous volume, it is held, must have come from outer sp to supply the gradual absorption of the gas from the atmosphe while by a reverse process of diffusion, the great amount of lil ated oxygen may have been got rid of, and the equilibrium of atmosphere in this way maintained. The consequences, both teorological and geological, of this process, were discussed by author in 1878, and more fully in 1880, in an essay on "' Chemical and Geological Relations of the Atmosphere," in American Journal of Science. As a further contribution to tl views, the author proceeded to show that Sir Isaac Newton only held to the presence in interstellar space of exhalations fi the sun, the earth, the fixed stars and the tails of comets, whicl supposed to become diffused and to form part of the ether, even suggested that this ethereal matter is the solar fuel, and sential to planetary life. From a consideration of the proce of vegetable growth and decay Newton arrived at the conclu that elements from interstellar space, brought by gravity wi the terrestrial atmosphere, serve to nourish vegetation, and by decay are converted into solid substances. In this way are, cording to him, generated not only combustible (sulphurec bodies, but calcareous and other stones, whereby the mass of planet is augmented. These views, put forward in Newton's " pothesis Concerning Light and Color," in 1675, and in the Que to the *Optics*, are more definitely enunciated in Propositions 41 42 of Book III of the *Principia*.

SYMMETRICAL METHOD OF ELIMINATION IN SIMPLE EQUATIONS, THE USE OF SOME OF THE PRINCIPLES OF DETERMINANTS.

JAMES D. WARNER, of Brooklyn, N. Y.

[ABSTRACT.]

THE general principle of forming a determinant from the efficients, and another by substitution of the independent te for the coëfficients of any one of the unknown quantities, finding the value of the unknown by dividing the value of latter determinant by the value of the first, will not be exem

fied, being in all books on determinants, and having been given already by some authors of algebra. It is thought that a long explanation of the method of multiplication might be omitted, if a rule specifying direction were given. The following is suggested, viz.:—after placing the known quantities in rows as directed, *i. e.*, forming the determinant, multiply each term of a row or column by all the other terms, so that if a line were drawn through the factors it would always be in a diagonal direction. The sign is to be changed for each change in direction from the positive. It is immaterial which direction is assumed for the positive direction; but the direction downward and to the right is generally taken for the positive direction.

There is a principle of determinants by which the same value is obtained, if we take the sum of the two determinants obtained by dividing into parts the terms of a row or column. By this principle we may resolve a row or column of either determinant into two parts, by taking one term from each of the others in a column or row, and then obtain the value by taking the sum of the products of each of the remainders, taken as a first minor, into its reciprocal, and the common part into the sum of these reciprocals.

In practice, it is best to place that column first which contains the unknown which is to be first obtained.

EXAMPLES.

Equations of two unknown quantities:—

$$\begin{array}{llll}
 & 6x - 9y = 9, & & \quad 28 \quad -28 \\
 & 2x + 7y = 13, & & \quad \underline{32 \quad\ \ 208} \\
2 + 4, -9 & & 9 \quad , -9 & \quad 60\ )\ \overline{180} \\
2 \quad\ \ , \ \ 7 & & 9 + 4, \quad 7 & \qquad \overline{x = 3}
\end{array}$$

$$\begin{array}{ll}
2x - \ \ y = \ \ 1, & \quad 5 \quad 15 \\
7x + 9y = 16, & \quad \underline{20 \quad 10} \\
 & \quad 25\ )\ \overline{25} \\
 & \qquad \overline{x = 1}
\end{array}$$

$$\begin{array}{ll}
5x + 4y = 26, & \\
6x + 4y = 28, & \quad -4\ )\ -8 \\
 & \qquad \overline{x = 2}
\end{array}$$

The following rule is obvious:

Take the sum of the two products obtained by multiplying the difference of terms of each column into that term of the other column which is in the same row as the subtrahend. The subtraction in each example must always be in the same direction, and

the rule of signs according to diagonal direction must be observed. This rule is useful in applying the method to elimination of equations of more than two unknown quantities.

Equations of three unknown quantities:—

$$\begin{aligned} 3x + 2y + 5z &= 59, \\ 4x + \ \ y + 3z &= 41, \\ 8x + 7y + 2z &= 75, \end{aligned}$$

$$\begin{array}{lrrrl}
4 - 1, 2, 5 & & & 59 & , 2, 5 \\
4 \quad\ , 1, 3 & & & 59 & - 18, 1, 3 \\
4 + 4, 7, 2 & & & 59 & + 16, 7, 2 \\
 & -19 & 19 & 767 & \\
 & 31 & 52 & -558 & \\
 & \underline{1} & \underline{4} & \underline{16} & \\
 & 13 & 75\ ) & \overline{225} & \\
 & & & \overline{x = 3} &
\end{array}$$

The first column, underneath the determinant, is the values of the reciprocals of the first minors. The second column is product of these reciprocals into the remainders, obtained from the first minors by subtracting the common part; that product which is zero being replaced by the product of the common part into the sum of the preceding column. The sum of the second column is the divisor sought which, after a similar proceeding after substitution of the independent terms, is used to divide the latter sum, the quotient being the unknown sought.

Equations of four unknown quantities:—

$$\begin{aligned} 3x + 2y + \ \ z + 3v &= 22 \\ 2x + 3y + 4z + \ \ v &= 24 \\ 5x + 5y + 3z + 2v &= 32 \\ 4x + 6y + 2z + 4v &= 38, \end{aligned}$$

$$\begin{array}{rrrrr}
3 \quad\ , 2, 1, 3 & 2 & & 32 - 10 & \\
3 - 1, 3, 4, 1 & 3 & & 32 - \ \ 8 & \\
3 + 2, 5, 3, 2 & 5 & & 32 \quad\ \ & \\
3 + 1, 6, 2, 4 & 6 & & 32 + 6\ \ & \\
24 - 32 - \ \ 8 = & -16 & & -24 & -160 \\
-16 + \ \ 8 + 24 = & 16 & & -16 & -128 \\
-66 + 14 + 20 = & -32 & & -64 & -256 \\
55 - 21 - 10 = & \underline{24} & & \underline{24} & \underline{144} \\
 & -8 & & -80\ ) & \overline{-320} \\
 & & & & \overline{x = 4}
\end{array}$$

For convenience in multiplying, the second column is to be written in order after the determinant. By considering that a determinant of the fourth order is formed from the sum of (12) (34), (13) (42), (14) (23), and these in inverted order, thus (34) (12), etc., it can readily be shown that the first row underneath the determinant is obtained from the first set by getting the value of the last minor of each, and multiplying by the first term indicated by the last figure of the other minor; while the second row is obtained by dividing each respective product of the first row by the fraction, formed by the terms, indicated by the last figure of the first minor, with the sign changed. The third and fourth rows are obtained in a similar manner from the second set. The sums of the several rows are then operated upon as explained for equations of three unknown quantities.

Equations of five unknown quantities:—

$$\begin{aligned}
x + 2y + 3z + 4v + 5w &= 6\\
2x + 4y + z - v + 2w &= 9\\
3x + 2y + z + 2v - w &= 2\\
4x + 3y + 2z + 2v + w &= 9\\
5x + 2y - 3z - 2v + 2w &= 10
\end{aligned}$$

$$\begin{array}{llllllllll}
3 - 2, & 2, & 3, & 4, & 5 & \quad 3 & 4 & \quad 9 - 3\\
3 - 1, & 4, & 1, & -1, & 2 & \quad 1 & -1 & \quad 9\\
3 & , 2, & 1, & 2, & -1 & \quad 1 & 2 & \quad 9 - 7\\
3 + 1, & 3, & 2, & 2, & 1 & \quad 2 & 2 & \\
3 + 2, & 2, & -3, & -2, & -2 & \quad -3 & -2 & \quad 9 + 1
\end{array}$$

$$\begin{array}{rrrr}
-8+4+8+2-8-8+27+12-18-12-18-6= & -25 & 50 & 75\\
-8+6+36-54-12-18+24+24-24-12-20-8= & -66 & 66 & -198\\
-117-52+6+4+42+14-4+24-2-16+8-40= & -133 & -66 & 931\\
-18-18+24+12+30+12-8+4+72+18+24+24= & 176 & 176 & \\
8-48+6+48-8+40+52-30-4+6-14-21= & 26 & 52 & 26\\
\hline
 & -22 & 278 &)\ 834\\
\hline
 & & & x = 3
\end{array}$$

For convenience, the third and fourth columns are written in order after the determinant.

By adding a unit to each figure of the sets forming a determinant of the fourth order, shown above, we may obtain the reciprocals of the first term of the determinant of the fifth order, thus: (23) (45), multiplying by the first term we have (1) (23) (45),

(1) (24) (53), etc.; by advance of each figure cyclically by a unit until the first figure would be repeated, the entire determinant of the fifth order will be obtained. By examination and comparison it can be seen how the even terms in each row can be obtained by multiplying the term preceding by a fraction, formed from the terms indicated by the second figure of the first minor of the second order, and dividing the product by a fraction formed by the terms indicated by the first figure of the same minor.

The value of a determinant is not altered if a row is added to or subtracted from another row, or a column is added to or subtracted from another column. This principle can be used to reduce large numbers to smaller ones, and to equalize the difference to the common part in a column.

EXAMPLES.

$$\begin{array}{rcrrr}
5x - 3y = 11 & 5, & -3 & 11 & -45 \\
15x + 2y = 66, & -10, & 17 & 11 & \underline{100} \\
 & & & & 55)\overline{220} \\
 & & & & x = 4
\end{array}$$

$$\begin{array}{rcrrrr}
7x + 11y = 40 & -13, & 19 & 4 & 36 & 10 \\
5x - \ \ 2y = \ \ 9, & 5, & -2 & 9 & \underline{-105} & \underline{-189} \\
 & & & & -69\,) & \overline{-179} \\
 & & & & & x = \frac{179}{69}
\end{array}$$

$$\begin{array}{rrrrrrrr}
7x + 5y + 2z = \ \ 79 & 6, & 1, & -3 & 24 & -1 & & -528 \\
8x + 7y + 9z = 122 & 6, & -1, & -1 & 12 & -17 & -132 & 204 \\
x + 4y + 5z = \ \ 55 & 1, & 4, & 5 & 55 & \underline{-4} & \underline{20} & \underline{-124} \\
 & & & & & -22 & -112) & \overline{-448} \\
 & & & & & & & x = 4
\end{array}$$

$$\begin{array}{rrr}
6x + 3y - 4z = 22 & 6, & 3, -4 \\
4x + \ \ y + 6z = 20 & 4, & -1, \ \ 6 \\
5x + 2y - 6z = 11 & 9, & 1, \ \ 0
\end{array}$$

$$\begin{array}{rrrrrrr}
1, & 1 & 11 & & & & 13 \\
-1, & -3 & 9 & 13 & -52 & 154 & 3 \\
5, & 2 & 11 & 21 & \underline{126} & \underline{-6} & \underline{-2} \\
 & & & & 74 &)\,\overline{148} & 14 \\
 & & & & & z = 2 &
\end{array}$$

The last column being the factors to be multiplied by the independent terms, reduced.

$$7x + 12y + 4z = 128$$
$$3x + 3y + 7z = 60$$
$$6x + y + 5z = 68$$

1, 11, — 1	60	8	— 16	
3, 3, 7	60	— 56	96	1920
6, 1, 5	68	80	240	640
		32	320)	2560
				$x = 8$;

Or

1, 10, — 1	60	35	— 70	352	— 176
3, 0, 7	60	— 45	180	— 192	— 368
6, — 5, 5	68	70	210	1940	480
		60	320)	1600	— 64
				$y = 5$;	

Or

1 10 9	— 600	300
3 0 7	— 240	— 980
6 — 5 0	1800	600
	) 960	— 80
	$z = 3$.	

Observe, that it is necessary to change the sign of the value obtained if, in subtracting, only one of the two determinants is operated upon and the remainder is on the same side of the minuend as the subtrahend.

Again, the substitution of the independent terms must not be made in a column which has been used to reduce another column. Neither must the substitution be made if a row has been used to reduce another row. For instance, in the last determinant shown only the value of z can be obtained; for the first column was used to reduce the second, and the reduced second was then used to reduce the third. Again, in the determinant preceding the last, the first column was used for reducing, and the value of x will not be obtained by direct substitution.

If it be desired to show the validity of these several principles, without reference to determinants, the ordinary equations used to show cross multiplication may be used.

Thus for equations of two unknown quantities:

$$x = \frac{cb_1 - c_1 b}{ab_1 - a_1 b} = \frac{(c - c_1)\, b_1 - c_1(b - b_1)}{(a - a_1)\, b_1 - a_1(b - b_1)},$$

For three take the denominator (the numerator can be operated similarly):

$$a_1(b_2c_3 - b_3c_2) + a_2(b_3c_1 - b_1c_3) + a_3(b_1c_2 - b_2c_1),$$

and show the first principle by the equality

$$a_1(b_2c_3 - b_3c_2 + b_3c_1 - b_1c_3 + b_1c_2 - b_2c_1) + (a_2 - a_1)(b_3c_1 - b_1c_3) + (a_3 - a_1)(b_1c_2 - b_2c_1),$$

and the second principle by the equalities,

$$(a_1 - b_1)(b_2c_3 - b_3c_2) + (a_2 - b_2)(b_3c_1 - b_1c_3) + (a_3 - b_3)(b_1c_2 - b_2c_1), \text{ or}$$
$$a_1\{(b_2 - c_2)c_3 - (b_3 - c_3)c_2\} + a_2\{(b_3 - c_3)c_1 - (b_2 - c_2)c_3\} + a_3\{(b_1 - c_1)c_2 - (b_2 - c_2)c_1\}, \text{ etc.}$$

No equations of a higher degree appear in any algebra, and those of four or five unknown quantities are so formed as to be eliminated by some trick not general; and as the method is easy in its application to equations of two and three unknown quantities, it is thought by the author that its use and the knowledge of the several principles of determinants necessary, ought to be shown to the student in algebra, in order that he may not only derive a benefit from the use of the method, but also to enlarge his ideas, by showing him this as a connecting link between numerical quantities, to which he has been accustomed, and expressed quantities, and also as an early introduction to determinants, which is of great use in his further advance in mathematics.

TITLES OF OTHER PAPERS READ IN SECTION A.

NUMERICAL ELEMENTS OF THE ORBITS OF THE SEVEN ELECTRICAL VORTICES, TO WHOSE MOTIONS ATMOSPHERIC STORMS ARE PRINCIPALLY DUE, WITH THE PROCESSES BY WHICH THEY HAVE BEEN DERIVED, AND EXAMPLES GIVEN OF THE APPLICATION OF THE FORMULA BY WHICH THEIR POSITIONS ON THE SURFACE OF THE EARTH CAN BE COMPUTED FOR ANY GIVEN TIME. By Thomas Bassnett, of Jacksonville, Fla.

UNIVERSAL ENERGY OF LIGHT[1]. By Pliny Earl Chase, of Haverford, Pa.

A NEW SYSTEM OF INTEREST, DISCOUNTS, ETC. By James W. Robinson, of Boston, Mass.

SUGGESTIONS FOR IMPROVEMENT IN THE MANUFACTURE OF GLASS, AND NEW METHODS FOR THE CONSTRUCTION OF LARGE TELESCOPIC LENSES. By G. W. Holley, of Niagara Falls, N. Y.

SCHEME EOR AIDING THE EULER'S TRANSFORMATIONS OF COÖRDINATES. By J. D. Warner, of Brooklyn, N. Y.

A MUSICAL LOCAL-TELEGRAPH ALPHABET. By William Boyd, of Cambridge, Mass.

ELECTRICITY, MAGNETISM, GRAVITATION:—THEIR PHENOMENA CONSIDERED AS THE MANIFESTATION OF ONE FORCE. By S. S. Parsons, of Lodi, Ohio.

THE SARASCOPE. By A. W. Brown, of Newport, Ky.

ON AN ABBREVIATION IN WRITING A LONG SERIES OF FIGURES, AND ITS USE IN CALCULATIONS. By Samuel J. Wallace, of Washington, D. C.

A NEW THEORY ON THE FORMATION OF HAIL. By C. R. Stuntz, of Cincinnati, Ohio.

ON THE WAVE-LENGTHS OF THE PRINCIPAL LINES OF THE SOLAR SPECTRUM. By T. C. Mendenhall, of Columbus, Ohio.

NOTE ON AN EXPERIMENTAL DETERMINATION OF THE VALUE OF π. By T. C. Mendenhall, of Columbus, Ohio.

REMARKS UPON, AND AN EXHIBITION OF JAPANESE MAGIC MIRRORS. By T. C. Mendenhall, of Columbus, Ohio.

[1] Printed in the Journal of the Franklin Institute, October, 1881.

NUMBERS OF COMETARY ORBITS RELATIVE TO PERIHELION DISTANCE. By H. A. Newton, of New Haven, Conn.

NOTE ON A COMPARISON OF NEWCOMB'S TABLES OF URANUS AND NEPTUNE, WITH THOSE OF THE SAME PLANETS BY LE VERRIER. By D. P. Todd, of Washington, D. C.

UPON THE USE OF THE INDUCTION BALANCE AS A MEANS OF DETERMINING THE LOCATION OF LEADEN BULLETS EMBEDDED IN THE HUMAN BODY. By Alexander Graham Bell, of Cambridge, Mass.

UPON A NEW FORM OF ELECTRIC PROBE. By Alexander Graham Bell, of Cambridge, Mass.

ON THE GREAT OUTBURST IN COMET B OF 1881, OBSERVED AT THE CINCINNATI OBSERVATORY. By Ormond Stone, of Mt. Lookout, Ohio.

A NEW RADIOMETER. By H. Carmichael, of Brunswick, Me.

A NEW DIFFERENTIAL THERMOMETER. By H. Carmichael, of Brunswick, Me.

THE NEEDLE TELEPHONE, A NEW INSTRUMENT BY DR. GOODMAN OF LOUISVILLE, KY. By J. Lawrence Smith, of Louisville, Ky.

NODULAR CONCRETIONS IN METEORIC IRON, BEARING ON THE ORIGIN OF SAME. By J. Lawrence Smith, of Louisville, Ky.

AN ANOMALOUS MAGNETIC PROPERTY OF A SPECIMEN OF IRON. By J. Lawrence Smith, of Louisville, Ky.

ON STANDARD TIME. By E. B. Elliot, of Washington, D. C.

THE ELECTROPHORE AND ELECTRIC LIGHTING. By E. B. Elliott, of Washington, D. C.

ON THE ERRORS TO WHICH SELF-REGISTERING CLINICAL THERMOMETERS ARE LIABLE. By Leonard Waldo, of New Haven, Conn.

ON THE FEATURES OF EQUIVALENCE TO CHEMICAL ELEMENTS, SHOWN BY ELECTRICITY AND HEAT. By Samuel J. Wallace, of Washington, D. C.

ON A SIGN OF LOGICAL CONNECTION IN EQUATIONS. By Samuel J. Wallace, of Washington, D. C.

PERMANENT

SUBSECTION OF CHEMISTRY.

PAPERS READ.

AMYLOSE. By H. W. WILEY, of Lafayette, Ind.

[ABSTRACT.][1]

term *amylose* is proposed for all sugars and sugar-like sub-s derived from starch. These substances are at present by a great many different names, thus often giving rise to lerstanding. Amylose is composed of three chief ingredients, extrine, dextrose and maltose. The specific rotatory pow-lextrine is a subject of much controversy. This arises from ficulty of obtaining pure dextrine. The numbers given by nt investigators vary from 150° to 186° for the yellow ray. ose is pure grape sugar. Its specific rotatory power for the is 50.°5. Maltose is an intermediate product between dex-ınd dextrose. It is an isomer of cane sugar and was first ghly studied by O'Sullivan. No satisfactory method has en devised for the separation and estimation of these several uents of amylose. Reduction of copper salts, fermentation olarization, all have their peculiar difficulties. The most ing method is by using both polarization and reduction.

IXED SUGARS. By H. W. WILEY, of Lafayette, Ind.

ED sugars are made of cane sugar and *amylose* (starch . Within a few years the mixed sugar industry has ad-l from a small beginning to a business of considerable im-ce. It is difficult to get accurate data of the amounts of gar made. Manufacturers and dealers are extremely reti-ı the whole subject, and often refuse to talk about it at all. , however, after considerable trouble, been able to get at the which will give at least an approximate estimate.

principal centres of the grape sugar industry are Brooklyn ew York, Buffalo and Peoria. From a careful comparison data which I have been able to collect, I place the daily

[1] The paper is published in full in "Science" for Oct. 1, 1881.

product of mixed sugars of the several factories at 1,500 barrels. This will be found not far from the truth. It is rather under than over the true number. It is thus seen that the mixing of sugars is a fact which is altogether too large to be laughed at. It must be remembered, too, that the manufacture is rapidly increasing, and is only limited now by the quantity of dry white amylose that can be made.

Amylose costs three and a half to four cents a pound by wholesale. Until the price of corn became so high it was half a cent less than this. It is, therefore, a very profitable business to mix it with cane sugar and sell the whole for the same price which the cane sugar would fetch alone. I have here on the table specimens of these mixed sugars. Here are eleven samples made by the Manhattan Refinery, of New York, also six samples from the Atlantic Refinery, of Buffalo, and six samples from Henry Hobart, of New York. These sugars are sold at retail under various names. Of these I may mention "New Process Sugar," "Niagara A B C", "Harlem B", "Excelsior C" and various others. To the eye these sugars look very much like straight cane sugars, and are generally pure and wholesome. They differ from the pure cane sugars in being less soluble in water and in being less sweet to the taste.

It has been estimated that amylose is two and a half times less sweet than sucrose; but this depends largely on the method of manufacture. Some samples of amylose will be found quite sweet, while others impart even a bitter taste.

In the manufacture of mixed sugars it is highly important that the amylose be dry. If hydrated amylose be used, it is found almost impossible to pulverize it, and when ground it is pasty and sticky. Machines have been patented for obtaining finely granulated amylose from the well dried specimens. It is quite impracticable, however, to obtain amylose entirely dry, and it is capable of being worked very well when it still contains 8 to 10 per cent. of water. This water is put in when sold at the same price as pure sucrose. In a commercial sense it is, therefore, not a disadvantage. The amylose which is used in mixing is generally made by high conversion under pressure. It therefore contains a high percentage of glucose (dextrose) as compared with the maltose and dextrine present. It is, therefore, less sweet to the taste than the liquid amylose, where the percentage of maltose is larger.

Many schemes for the estimation of the different constituents of a mixed sugar have been proposed. For a discussion of the methods of analysis by reduction and fermentation, I refer to my paper on amylose. I will content myself here with a brief outline of the method which I have employed. The water is estimated by heating two or three grammes in a flat platinum dish to 150° C. for two hours. The percentage of cane sugar I determine by Clerget's method. First get the total rotation in the polariscope, then invert by heating to 68° with H Cl, then polarize again, carefully noting the temperature. From these readings the percentage of cane sugar present is calculated from the following formula:

$$x = \frac{a - a'}{144 - \frac{t}{2}}$$

Here a = first reading of polariscope.
a′ = second reading of polariscope.
t = temperature of observation.
x = percentage cane sugar required.

In connection with the polariscope readings I also made reductions both before and after inversion, and thus obtained valuable data in regard to the nature of the amylose present, as well as securing a check on the optical results.

Following is a scheme of an analysis which will illustrate the method of procedure.

Reduction. Took 10 g. in 1000 cc. Of this, to reduce 10 cc. Fehling's Solution, took 27.8 cc.

Then 1000 : 27.8 = x : .05 (.05 g. = sugar corresponding to 10 cc. copper solution).

Whence x = 1.8 g. = 18 per cent. reducing matter.

Polarization. 26.048 g. in 100 cc. gave . . . . 97°.8+
After inversion at 21° " . . . . 2°.6—

Difference, = ... 100°.4

$$100°.4 \div 144 - \frac{21}{2} = 75.2 \text{ per cent. sucrose.}$$

Reduction after inversion.
For 10 cc. copper solution took 5.35 cc.
Then 1000 : 5.35 = x : .05.
x = 9.35 g. = ... 93.50 per cent.

Deduct 18 per cent. due to amylose gives
due to invert sugar . . . . . 75.50 per cent.
Sucrose by polariscope . . . . 75.2 "
Amylose, water and ash by difference . 24.8 "

Following are the results of twelve examinations of mixed sugar:

No.	Per cent. Reducing Matter.	Per cent. Sucrose by Polariscope.	Amylose, Water, Ash, etc., by difference.	No.	Per cent. Reducing Matter.	Per cent. Sucrose by Polariscope.	Amylose, Water, Ash, etc., by difference.
1	[1]29.70	[1]71.4	28.6	7	26.88	60.7	39.30
2	24.6	64.35	35.65	8	25.00	68.6	31.40
3	25.64	68.2	31.80	9	30.5	59.9	40.10
4	25.00	64.72	35.28	10	25.8	71.6	28.40
5	22.52	66.80	33.20	11	26.6	61.0	39.00
6	24.4	60.34	39.66	12	18.0	75.4	24.60

The analysis of mixed sugars is at this time a matter of great public interest. It is important that the public be not defrauded by purchasing sugars under false names. It is true that the manufacturers, as far as I know, do not sell the mixed sugars as straight, but when they pass into the hands of the retail dealers they are usually disposed of as if they were genuine. I do not anticipate that mixed sugars will jeopardize the public health. When well made they are certainly palatable and harmless. For boiling with fruits, etc., as in making preserves, they are quite as efficient as cane sugars. Nevertheless, a "mixed sugar" should be bought, sold, and consumed as a mixed sugar, and thus all "winking" at fraud be prevented.

[1] One of these numbers is evidently incorrect. On looking over my notes I cannot find the mistake, and I have no more of the sugar with which to repeat the analysis. I think the error is in the per cent. of reducing matter.—H. W. W.

Relation of Reducing Power, as measured by Fehling's Solution to the Rotatory Power of Commercial Amylose (Glucose or Starch Sugar). By H. W. Wiley, of Lafayette, Ind.

In a paper read at the Boston meeting of this Association[1] I called attention to the fact that the reducing power of amylose, measured by Fehling's Solution could be readily determined by the polariscope. Since that time I have extended the series of observations then reported, and with such results as justify the conclusions at which I arrived.

In commercial amyloses, whose specific gravities do not vary much from 1.410, the reducing power is reliably calculated from the reading of the polariscope. The average percentage of water in these amyloses is nearly thirteen. If we allow one per cent. for optically inactive substances present, we may safely place the optically active matter at 86 per cent. By prolonged boiling with acids, even if they be quite concentrated, only about 82 per cent. of reducing matter is obtained.[2] Further boiling causes the mass to turn brown, and may even cause a decrease in the amount of reducing matter found. Since there is so much difference of opinion respecting the reliability of Fehling's solution, and since there is no other reducing mixture that works as well, it would, perhaps, be better to use the polariscope for the determination of the amount of substances present in an amylose capable of reducing the various solutions used for grape sugar measurements.

In the following table the calculation of the reducing power was made by the formulæ which I have already explained.[3] Although, in a few cases, the specific gravity varied by a few thousandths from 1.410, the difference has not been of sufficient importance to make any correction[4].

Since the ordinary amyloses, called grape sugars, of commerce, differ from those called glucoses only in having the processes of conversion carried further, it is found that the same rule applies to them also. In fact, I believe it will be found true with all varieties of amylose made by use of sulphuric acid, provided 8.6 grammes of the anhydrous substance be used in each 100 c.c. of the mixture to be examined.

[1] Proceedings of this Association, 1880, p. 308; Journal Am. Chem. Soc., Vol. II. p. 387.
[2] Proceedings A. A. A. S., 1880, p. 320. Journal Am. Chem. Soc., Vol. II, p. 399.
[3] Proceedings A. A. A. S., 1880, p. 313. Journal Am. Chem. Soc., Vol. II, p. 393.
[4] Proceedings A. A. A. S., 1880, p. 316. Journal Am. Chem. Soc., Vol. II, p. 395.

Following are the results of my observations:

TABLE I.

No.	Sp. gravity.	Reducing matter by Fehling's Solution.	Rotation of 10 g. in 100 c.c. cane sugar scale.	Reducing matter calculated by Polariscope.	Difference.		Date of Manufacture.
					+	−	1880.
1	1.414	52.1	53.40	52.50	0.40	...	September 15
2	1.419	52.2	53.00	53.00	0.80	...	" 14
3	1.410	53.8	51.00	55.50	1.70	...	" 15
4	.....	53.2	55.50	49.90	....	3.3	October 12
5	1.412	51.0	54.10	51.60	0.60	...	" 18
6	1.413	51.1	53.20	52.75	1.65	...	" 19
7	1.417	51.6	53.45	52.44	0.84	...	" 19
8	1.417	49.7	55.20	50.30	0.60	...	" 20
9	1.408	49.0	55.50	49.90	0.90	...	" 21
10	1.413	49.5	55.40	50.00	0.50	...	" 21
11	1.411	48.1	56.60	48.50	0.40	...	" 17
12	1.421	48.8	56.40	48.80	0.00	0.0	" 16
13	1.417	50.0	57.00	48.00	....	2.0	" 16
14	1.413	46.4	56.70	48.40	2.00	...	" 14
15	1.417	48.1	56.50	48.60	0.50	...	" 14
16	1.418	46.3	58.20	46.50	0.20	...	" 13
17	1.412	47.2	57.00	48.00	0.80	...	" 12
18	.....	72.0	37.30	72.63	0.63	...	Unknown.

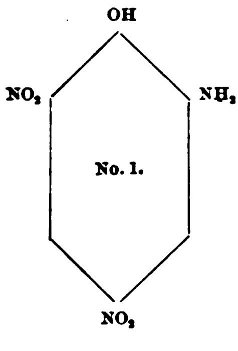
The above analyses were of samples sent by the manufacturers, the Peoria Grape Sugar Company. They represent the whole number of samples examined and in the order in which the analyses were made. Seventeen of them were of syrups, and the eighteenth of a solid sugar. Only four out of the eighteen show discordant results. In one of these the specific gravity was not determined. It was my intention to make these four analyses in duplicate, but a press of other business prevented. In general, it appears that the results given by the polariscope, by the above method of calculation, are a little too high. If they were diminished by .5 the agreement would be better. That the reducing power of amylose can be correctly calculated from its rotatory power is certainly established from the thirty-eight unselected instances which have been presented in this and my former paper.

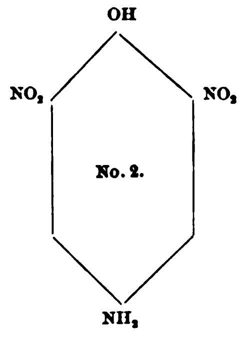
AN ISOPICRAMINIC ACID. By CHAS. W. DABNEY, of Raleigh, N. C.

PICRAMINIC acid, $C_6 H_5 N_3 O_5$, was discovered by Wöhler. It is prepared from picric acid by reducing one of the nitro groups with various reducing agents. Picric acid is a diorthoparanitrophenol $C_6 H_2 \overset{I}{O}H, 2N\overset{o}{O}_2 N\overset{p}{O}_2$. This is established by the fact that it is made as well from α as from β dinitrophenol.

That the amido group in picraminic acid is in one of the ortho positions is proven by the following argument:—A dinitrobenzoylamidophenol has been made from the well known orthobenzoylamidophenol, $C_6 H_4, \overset{I}{O}H, N\overset{o}{H}COC_6 H_5$, and its mononitro derivative paranitroorthobenzoylamidophenol, $C_6 H_3 \overset{I}{O}H, N\overset{p}{O}_2, N\overset{o}{H}COC_6 H$. This by splitting off the benzoyl group yielded the well known picraminic acid. And the picraminic acid so prepared has been reduced to the familiar orthoparanitrophenol by removing the amido group.

Further the benzoyl derivative of picraminic acid yielded the anhydro compound, which is only possible when the amido group stands in the ortho position to the hydroxyl group. The constitution of picraminic acid is therefore to be represented by graphical formula, figure No. 1:—





The Isopicraminic acid to be here noticed was obtained by indirect methods starting from α metanitrosalicylic acid. This is converted into the corresponding benzoylamido acid, $C_6 H_3$, COOH, OH, $NHCOC_6 H_5$. As a new body this was duly investigated. By nitrating this I got a dinitrophenol through the elimination of the carboxyl group. This is the benzoyl derivative of the new picra-

minic acid and the acid is obtained from it by splitting off the benzoyl group.

The new acid and its derivative were compared with the known picraminic acid and its benzoyl derivative. The bodies themselves and all their salts were found to differ markedly. The isomerism is to be explained as follows:— It has been proven that the amido group in metamidosalicylic acid from which it is derived is in the para position to the hydroxyl. This is sufficient to explain the isomerism since it was shown that the amido group is ortho to the hydroxyl group in the known picraminic acid. The constitution of the new acid is represented in contrast with that of the known by figure No. 2.

N. B. For figures and details see dissertation Göttingen, 1880.

THE LIMITED BIOLOGICAL IMPORTANCE OF SYNTHETIC ACHIEVEMENTS IN ORGANIC CHEMISTRY. By A. B. PRESCOTT, of Ann Arbor, Mich.

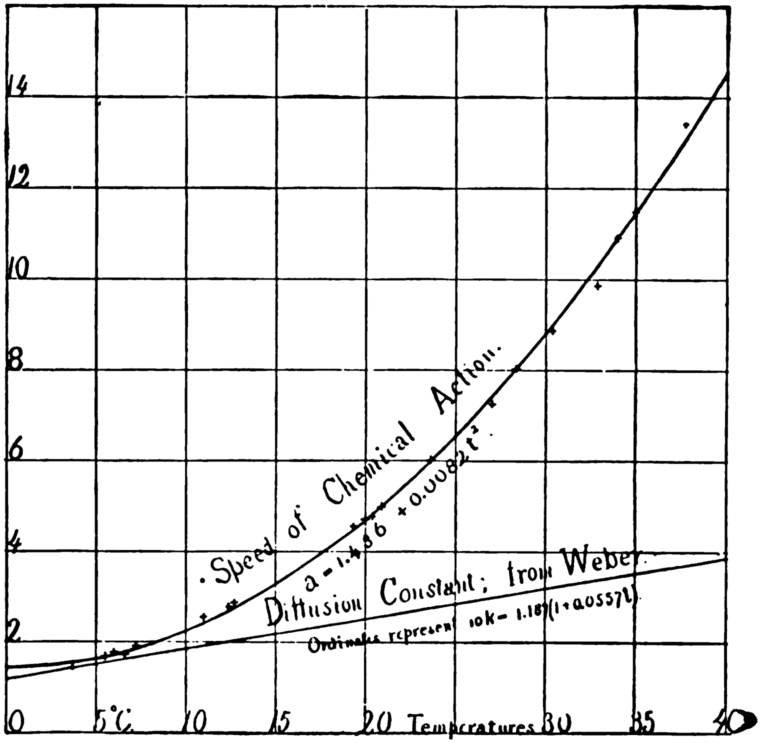
[ABSTRACT.]

FOR half a century there has been a degree of solicitude as to the biological bearing of organic chemical synthesis. This has been due to uncertain and mistaken conceptions of the scope of chemical action. It has been assumed that, if we admit the existence of chemical action in living tissues, we must ascribe cell structure and perhaps even vital functions to this chemical action and must conceive it as being independent of the activities peculiar to living tissues. There ought to be no doubt about organic matter being in a state of chemical union, for the elements carbon, hydrogen, nitrogen, and oxygen, are evidently not chemically free in the proteid tissue substances. Having now a more definite recognition of the chemical character of all matter, in the modern idea of the molecule, it is evident (1) that the matter of protoplasm is at all events in a state of chemical combination. But (2) it by no means follows that chemical action supplies protoplasm with its power for cell organization. As chemism (the pro-

duction of molecules) is distinct from cohesion and adhesion (certain aggregations of molecules), it is even more in contrast with cell formation (a specific aggregation of molecules). Mutual co-relations have been established between chemism on the one hand, and cohesion and adhesion, also heat, etc., on the other hand. We say that chemical action is wholly dependent upon conditions, that is, influences, of cohesion and adhesion (solubilities), and of heat (temperatures), etc. But no one denies the chemical nature of a compound because non-chemical activities are essential to its production. Now very few co-relations between chemism and cell growth have been ascertained. But some do demur as to the chemical nature of the material giving origin to cells. The existence of constant co-relations between chemical action and cell formation is highly probable. An example is declared in the alcoholic fermentation. The simple splitting of sugar into alcohol and carbon dioxide, a definite chemical change, in direction toward the inorganic, is wholly dependent on cell-growth. The chemical synthesis of proteids, and other bodies, may be found to require cell growth. On the other hand, it may be found that some other activity can supply the place of the yeast-cell, in the conversion of sugar into alcohol, etc.; and inorganic activities may substitute those of the cell in providing for various organic syntheses. Whether any coöperation of chemical activities, with inorganic materials and helps, can synthesize a protoplasm that can start a cell, is just the old question of abiogenesis, *with addition* of some questions of organic chemical syntheses. They have experimented as to abiogenesis, taking proteids ready made (and experiment alone can decide). The synthesis of proteids from inorganic sources would not have the least bearing on questions of spontaneous generation. The vegetable cell-wall is nearly pure cellulose, a chemical compound so simple and stable that it is likely to be attained by the chemist as a so-called artificial product. But it will be no easier to raise cells out of artificial cellulose than it is to raise cells out of the amorphous vegetable cellulose that the chemist precipitates by acidulating its cuprammonium solution. Chemical action is separated as by a gulf from the aggregation of molecules into cells. Across this gulf, as across all boundary lines in nature, there may be cables of mutual influence. But these co-relations must be found before they can be assumed as the basis of doctrine.

EVIDENCE OF ATOMIC MOTION WITHIN LIQUID MOLECULES, AS BASED UPON THE SPEED OF CHEMICAL ACTION. By R. B. WARDER, of North Bend, Ohio.

THE experimental evidence upon which the argument of this paper is based has already been published; namely, my own determinations of the speed of the saponification of acetic ether at different temperatures (Ber. d. c. G., 14, 1361) and Weber's determinations of liquid diffusion (Wied. Ann., 71, 469 and 536).



From the twenty determinations of the speed of saponification just cited (which are indicated in the accompanying figure) I have deduced an empirical formula of the form

$$a = A + B t^2$$

where a denotes the "coëfficient of speed" and t is the temperature of the mixture. Weber shows, on the other hand (*loc. cit.*,

page 549), that the diffusion constant varies nearly according to the linear equation,

$$k = A' + B' t.$$

These two lines are also presented in the diagram, the ordinates of the latter being multiplied by ten to facilitate the comparison.

Now when chemical action takes place in a very dilute solution, the action will often be retarded for hours or days; the unlike molecules cannot react upon each other unless they are brought very near together; and in what we call a homogeneous fluid, this takes place by diffusion. Any change of conditions by which the diffusion is increased may likewise increase the speed of chemical action. But while the increase in the diffusion constant, for dilute solutions, varies nearly as the first power of the temperature, the increase of chemical action (in the case before us) is nearly as the second power of the temperature. From these facts I conclude that the increase in the rate of diffusion alone is not sufficient to account for the increased rate of chemical action, and a second cause for the increased speed of the reaction must be sought in the atomic motion within the liquid molecules. If the amplitude of the atomic vibrations or orbits is increased by raising the temperature (no matter what the nature of those vibrations may be), we must suppose that they recede farther from the conditions of mean equilibrium, the stability of the molecule would probably be diminished thereby, and the frequency of the metathesis would accordingly be increased, as shown by the determinations already published.

The Chemical Composition of Fish and Invertebrates. By W. O. Atwater, of Middletown, Conn.

[ABSTRACT.]

At the Boston meeting of the Association, an account was given of analyses of the flesh of a number of species of fish used as food, the work being part of an investigation of the chemistry and economic values of American food-fishes and invertebrates, undertaken under the auspices of the Smithsonian Institution and U. S. Fish Commission. The present paper gives an account of

the progress of the research during the past year. The number of samples thus far analyzed includes fifty-one of fishes, representing twenty-eight species, and twenty-five of invertebrates, representing five species, making altogether, seventy-six samples representing thirty-three species. The results of the analyses of fish are mainly confirmatory and in amplification of those reported a year ago.

The analyses of invertebrates, oysters, clams, scallops, lobsters, and cray-fish, bring out some facts of interest.

The samples of oysters showed much wider variations than might have been anticipated both in the proportions of shell contents, solid and liquid, and in the amounts of actually nutritive materials contained in them. In general, the oysters from the coasts of New England and New York were much richer both in total shell contents and in actual nutrients, than those from southern localities, Norfolk, and the Potomac, James and Rappahannock rivers. Thus the samples from East river (N. Y.) and Buzzard's bay had respectively 20 and 20.3 per cent. of shell contents, while those from the James and the Potomac had 13.8 and 12.1 per cent., and one from Norfolk only 11.2 per cent. That is, of the whole weight of the East river and Buzzard's bay samples, four-fifths were shell and one-fifth "meat and juice," while in the southern samples the shell contents made only one-eighth of the whole weight.

The ratios of solids to liquids, in the shell contents were still more variable. A sample of Blue Points had 13.4 per cent. solids and 5.3 per cent. liquids, and one of Stony Creeks 7.3 per cent. solids and 11.8 per cent. liquids. The percentages of solids ranged from 13.4 per cent. in the Blue Points to 4.7 per cent. in the Norfolks; those of liquids from 11.8 in Stony Creeks to 4.9 in Shrewsburys.

The actual nutrients, however, are to be found in the dry (water-free) substance of the shell contents. Here again we find wide variations. Thus in the flesh (solids) the percentages of dry substance run from 23.7 in the Blue Points to 15.5 in the Staten Islands, while the liquids contain from 6.0 per cent. of actual solid matter in the Fair Havens to 2.8 per cent. in the Rappahannocks. Taking the total shell contents, flesh and liquids together, we have in the Blue Points 19.2, and in the Norfolks only 8.6 per cent. of nutritive substances, the rest being water.

As regards the constituents of the flesh, that of oysters is

found to be quite watery, as would be expected, and to contain but little fat. On the average the flesh (solid) of oysters like that of fish, contains a little more water and less dry substance than ordinary meats. The oysters seldom have much fat while some fish have a great deal.

Clams are similar in composition to oysters, though rather richer in nutritive materials. Scallops (the adductor muscle, the portion commonly eaten), are still richer both in total nutrients and in fats. The amount of nutritive matter in lobsters and crayfish is very small.

Quite extended statistics were given of results of the study of the constitution of the flesh of the different animals; but the subject, though of more scientific interest than the economic valuations, can hardly be set forth in a brief abstract. It is proposed to continue the investigation in the more abstract, as well as the more practical, phases for some time to come, the work thus far being regarded as only a beginning. A detailed account of the investigation is to appear in the forthcoming report of the U. S. Fish Commission.

The Determination of Nitrogen. By W. O. Atwater, of Middletown, Conn.

[ABSTRACT.]

This paper called attention to two sources of error frequently overlooked in the estimation of nitrogen by the absolute method.

One is found in the air which adheres to the combustion tube and its contents, even after protracted exhaustion by the Sprengel pump. Blank determinations with pure oxalic acid gave, in four determinations, 0.3cc., 0.6cc., 0.5cc., and 0.6cc., averaging 0.5cc. of nitrogen.

Another error is the disregarding of the vapor tension of the caustic potash solution over which the nitrogen is collected in the eudiometer. In accurate work this is hardly allowable. Even a 50 per cent. potash solution gives an appreciable vapor tension as has been shown by Wüllner (*Pogg. Annalen*, 110, p. 570), who gives a formula for calculating the tension.

By avoiding these errors and using other needful precautions, the determinations can be made with most satisfactory results.

COAL DUST AS AN ELEMENT OF DANGER IN MINING; SHOWN BY THE EXPLOSION IN THE ALBION MINES, NOV. 12, 1880. By H. C. HOVEY, of New Haven, Conn.

A preliminary glance at the history of the Albion Mines, in Nova Scotia, will aid us to understand the part played by coal dust in spreading and augmenting the explosion that destroyed those mines less than a year ago.

The Main Seam is 37 feet 6 inches thick, and is highly bituminous. It has been continuously worked since 1807. The earliest workings were abandoned in 1839, on account of a fire that burned so fiercely as to melt the chains used in raising the coal-tubs. A new opening, the Bye Pit, was worked till 1863, when a fire occurred from a shot lighting gas, and the pit had to be closed up. The Foster Pit was next opened; but in 1869 spontaneous combustion of slack caused a fire which necessitated its abandonment.

At length the Foord Pit was won out, and with its improved machinery, was regarded as one of the best mining establishments in America. The ventilation was effected by a large Guibal fan, said to be capable of circulating 120,000 cubic feet of air per minute through the ramifications of the mine. The drawing shaft is 1,000 feet deep, and the workings extend 1,800 yards to the north, and 1,700 yards to the south, the galleries varying from 9 to 15 feet in height, being driven in the upper part, the lower being left for later operations. Shortly before the accident referred to, I went entirely through the colliery, in company with Mr. Edwin Gilpin, Inspector of Mines, and we remarked the perfection of the ventilation, which was then maintained through the south-side at the average rate of 25,000 feet per minute, and expelled the deleterious gases from even the remotest bords.

On the morning of the disaster the night watchman reported the mine to be free from gas, except in small and harmless quantities. From what source, then, originated the series of explosions that began, within an hour from the time this report of entire safety was made, and continued at intervals until the mine became a furnace, whose flames could be subdued only by emptying into its burning chambers the waters of the adjacent East River? Was there some sudden exudation of gas from the solid coal? Or was this explosion due to the firing of coal dust from the flame of a

blast, an unsound safety-lamp, or even a match by which some unlucky workman, forgetful of the rules, undertook to light his pipe?

None of the forty-four men who witnessed the beginning of the catastrophe escaped to explain the mystery; and those rescued from more distant galleries had but conjectures to offer.

The workmen, on receiving assurance that the mine was free from gas, went down the drawing-shaft, took their safety-lamps at the lamp-cabin and went, a part of them into the north-side works, and the rest into the south-side dips, where they waited for their tools. At this moment, the explosion took place. It was first noticed at the fan-shaft, and a minute later at the drawing-shaft, having in one case travelled with and in the other against the ventilating current. Additional facts were gained, at the imminent risk of life, by Mr. Gilpin, and are as follows:

The exploring party went as far as the after-damp would allow. The locality where the workmen were known to be was 1,200 yards south of the shaft, and the party went about 600 yards in that direction. It was evident to them that the flame had not reached so far, for no marks of fire were on the dead bodies found, nor was the splintered woodwork charred. The walls looked as if swept by a broom, and were clear of timber. Volumes of dust lay on the floor, into which the party often sank to their knees. Clouds of finer particles were swept on into the north-side levels. At the lamp-cabin an open light had been kept burning for years, as it was considered safe, being within a few feet of the bottom of the shaft.

But here a secondary *explosion* took place, demolishing the cabin, fatally injuring the lamp-man, and burning the horses near by. The effect did not extend far into the north-side, and the men there were ignorant of the disaster, till warned by the overman to leave the pit. Secondary explosions, caused by generated, or extracted, gas, are usually near the primary one. But here is a case where the second was half a mile from the first, with an intervening space of a quarter of a mile known to be free from gas, because men were in it with lamps which gave no sign of its presence.

The ignition of these volumes of dust did not harm the shafting, because it was wet, and the flame was extinguished as soon as it touched the damp walls. Elsewhere this mine was a very dry one.

After the exploring party came to the surface, attempts were made to restore ventilation; when the presence of a large fire was discovered. In forty-eight hours water was let in from East River, at the rate of 15,000 gallons per minute, until the whole mine was flooded. This, of course, stopped investigations, and nothing may ever be known beyond what is here told.

Comparing the above facts with the experiments of Galloway, Abel, and others, my conclusions are as follows:

1. That coal-dust, under favorable circumstances, becomes the vehicle of flame.
2. That it may spread and augment gas-explosions.
3. That it may determine and precipitate explosions due to the presence of inflammable gas in otherwise harmless and scarcely appreciable quantities.
4. That it would be a wise precaution to water dusty galleries,—a practice that would, at least, tend to reduce the range of dust explosions.

A Chemical Examination of Gluco-maize Residue. By C. Gilbert Wheeler, of Chicago, Ill.

By gluco-maize residue I mean the residue left in the manufacture of glucose from maize or Indian corn.

Enormous quantities of this material now accumulate at the glucose factories in the West, being thus far utilized to only a slight extent. It is somewhat employed as a fodder, but as it so readily sours in its natural moist condition, it has thus far met with only a limited local demand.

Experiments now being made, however, to ascertain the practicability of drying, pressing and rendering conveniently transportable this, as yet, waste product, have also given to the chemical investigation of the gluco-maize residue an importance worthy of some consideration. It may here be stated that in connection with the practical preparation of the residue for market, a press has been devised which operating by means of blows—like a pile-driver—gives greater results as to compression than any hydraulic or other

press thus far invented. This at least is claimed for the invention. A careful analysis of the material, made as fine as possible by appropriate mechanical treatment and then thoroughly mixed, gave the following results:

Water,	41.000
Ash,	.177
Fat,	5.128
Nitrogen-free Extract,	42.066
Fibre,	2.555
Albuminoids (Protein),	9.074
	100.00

The above is the mean of two complete analyses which gave very concordant results. The ash was obtained by ignition for about twenty-four hours in a platinum dish at a temperature barely reaching the faintest redness. There was no unconsumed charcoal left on completing the ignition. The fat was obtained by prolonged treatment with ether of the very finely subdivided material. The water was determined by driving off the same at a temperature a little above 100°.

For purposes of comparison, the results as dry material are here subjoined with analyses of maize also distillers' grains taken from Kühnes tables.

	Gluco-maize Residue.		Fifty-two Specimens of Maize.		Distillers' Grains.	
	Moist.	*Dry.*	Range.	Average.	Maize.	Rye.
			Dry.	*Dry.*	*Dry.*	*Dry.*
Water,	41.000					
Protein or nitrogenous matter,	9.074	15.38	8.7—14.4	12.0	21.3	20.4
Fat,	5.128	8.69	4.4—7.8	5.7	10.5	4 3
Nitrogen, free extract,	42.066	71.30	75.2—82.2	78.7	52.1	56 9
Crude fibre,	2.555	4.33	0.3—3.00	1.9	10.4	12.9
Ash,	0.177	0.30	1.3—2.0	1.7	5.2	5.5
	100.000	100.00		100.0	99.5	100.0

The nutritive value of the gluco-maize residue is here shown to be very much in excess of that of the original maize. It apparently only lacks somewhat in mineral matter to preclude its being

regarded as an almost perfect fodder. In the preparation, however of this material for purposes of transportation and sale, the requisite saline additions could be readily made.

A careful examination of the ash of the residue gave:

Silica,	7.45
Calcium oxide,	31.16
Potassium oxide,	24.70
Ferric oxide,	19.08
Phosphoric acid,	17.17

As might be expected the treatment of the maize in the manufacture of glucose not only reduces the amount of mineral matter but also changes its relative composition. The very large amount of iron found is probably, however, due to the nature of the vessels employed in this industry and the analysis therefore gives no right to the inference that so much of this element is contributed by the grain itself. The absence of magnesium salts is also to be noted. On the whole, gluco-maize residue properly dried, compacted and seasoned with appropriate mineral matter may be regarded as a welcome addition to our list of fodders.

PENTACHLORAMYL FORMATE. By ALFRED SPRINGER, of Cincinnati, Ohio.

FORMED by passing dry chlorine through amyl formate from five to six days.

The amyl formate is placed in a tube corresponding to a quarter circle and set out to the effect of sunlight as long as the chlorine is passed through it. When the operation is completed carbonic acid is then passed through until all the free chlorine, hydrochloric acid, chlor amyl, etc., are expelled.

The whole operation is then repeated.

Pentachloramyl formate is a heavy, colorless liquid which de-

composes in seven weeks when kept in the dark, in three weeks when exposed to the light.

Specific gravity is 1.52.

When heated to 108° it turns brown, at 120° almost black. Water of 70° decomposes it, therefore it cannot be distilled by itself nor with water.

Formula $C_6 H_7 Cl_5 O_2$.

I am inclined to think it ought to be regarded as a chlorocarbonate of tetrachloramyl, for the reason that the ammonia salt which I am at present examining seems to exhibit all the reactions of a urethane or neutral carbamic ether in which the hydrogen of the hydroxyl is substituted by tetrachloramyl.

TITLES OF OTHER PAPERS READ BEFORE THE SUB-SECTION OF. CHEMISTRY.

THE NITROGENOUS CONSTITUENTS OF GRASSES. By Clifford Richardson, of Washington, D. C.

MINERALOGICAL NOTES[1]. By Benjamin Silliman, of New Haven, Conn.

COMPOSITION AND QUALITY OF AMERICAN WINES[2]. By Henry B. Parsons, of Washington, D. C.

ON CHLORTRIBROMPROPIONIC ACID. By C. F. Mabery and H. C. Weber, of Cambridge, Mass.

IS THE LAW OF REPETITION THE DYNAMIC LAW UNDERLYING THE SCIENCE OF CHEMISTRY? By Miss Virginia K. Bowers, of Perry Co., Mo.

THE CONSTITUTION OF THE "ATOM" OF SCIENCE[3]. By Mrs. A. B. Blackwell, of Somerville, N. J.

[1] Printed in American Journal of Science, Sept., 1881.
[2] Printed in U. S. Agricultural Report.
[3] An abstract of this paper is given in Science, Sept. 17, 1881.

ON DIBROMIODACRYLIC AND CHLORBROMIODACRYLIC ACIDS. By C. F. Mabery and Rachel Lloyd, of Cambridge, Mass.

ON A NEW MATERIAL SUITABLE FOR STOP-COCKS AND STOPPERS FOR REAGENT BOTTLES[4]. By H. W. Wiley, of Lafayette, Ind.

NOTES IN EXPERIMENTAL CHEMISTRY. By Albert B. Prescott, of Ann Arbor, Mich.

AN ATTACHMENT FOR BURETTES AVOIDING THE NECESSITY OF USING STOP-COCKS. By Fr. A. Roeder, of Cincinnati, Ohio.

ON A NEW FORM OF BALANCES. By Fr. A. Roeder, of Cincinnati, Ohio.

THE LIQUEFACTION OF GLASS IN CONTACT WITH WATER AT 250° C. By H. Carmichael, of Brunswick, Me.

A FILTRATION EVAPORATION BALANCE. By H. Carmichael, of Brunswick, Me.

THE QUANTITATIVE ESTIMATION OF CHLORINE. By W. O. Atwater, of Middletown, Conn.

THE SOURCES OF THE NITROGEN OF PLANTS. By W. O. Atwater, of Middletown, Conn.

SOME NEW FORMS OF APPARATUS FOR THE CHEMICAL LABORATORY. By G. C. Caldwell, of Ithaca, N. Y.

DEVELOPMENT OF SUGAR IN MAIZE AND SORGHUMS[5]. By Peter Collier, of Washington, D. C.

DETERMINATION OF PHOSPHORUS IN IRON. By J. Lawrence Smith, of Louisville, Ky.

REGULATOR OF FILTER PUMPS. By J. Lawrence Smith, of Louisville, Ky.

HIDDENITE, A NEW AMERICAN GEM. By J. Lawrence Smith, of Louisville, Ky.

IRON WITH ANOMALOUS CHEMICAL PROPERTIES. By J. Lawrence Smith, of Louisville, Ky.

ALCHEMY, THE CRADLE OF CHEMISTRY[6]. By H. Carrington Bolton, of Hartford, Ct.

[4] An abstract of this paper is printed in Science of Sept. 17, 1881.
[5] Printed in U. S. Agricultural Report.
[6] This was given as an evening lecture and was illustrated by lantern views.

PERMANENT

SUBSECTION OF MICROSCOPY.

PAPERS READ.

RIBUTION TO THE STUDY OF THE BACTERIAL ORGANISMS IMONLY FOUND UPON EXPOSED MUCOUS SURFACES AND IN : ALIMENTARY CANAL OF HEALTHY INDIVIDUALS.[1] By GEO. STERNBERG.[2]

[ABSTRACT.]

INTRODUCTION.

observations recorded in this paper and the photo-micro-)y which it is illustrated, were made in the biological labora- Johns Hopkins University, Baltimore, Md., while the writer ;aged in pursuing special investigations under the direction Vational Board of Health.

oscopists have long been familiar with the fact that a of bacteria are constantly found in the alimentary canal hy individuals, and that the examination of saliva or fæces, ufficiently high power, never fails to demonstrate the pres- a multitude of these micro-organisms of various forms. icroscopists to whom this fact is familiar, and whose studies own them the widely extended distribution of the bacteria, thin and without the human body, have shown a disposition ule the idea that these minute organisms so universally are capable under any circumstances of playing so import-)le in the etiology of infectious and epidemic diseases as n ascribed to them by believers in the "germ theory."

st be admitted that many extravagant and unfounded claims ;en made by some of the over-enthusiastic supporters of ory, and that a scientific conservatism is very essential to o would estimate at their true value the facts developed

. this paper was read it was illustrated by three photo-micrographic plates, fortunately, cannot be reproduced on account of the expense. The paper been published in full, with three heliotype plates, in the "Biological Studies" ns Hopkins University.

)n United States Army.

by the numerous researches which have been made relating to the bacteria. The literature of the subject is already enormous, and the yearly additions to it seem to be almost in geometrical progression, showing the rapidly increasing interest in the subject among physicians, sanitarians, and men of science generally, due to a more general appreciation of the importance of the questions involved.[3]

It is evident that the time has passed when the spirit of investigation can be arrested by the exhibition, under the microscope, of the bacteria found in the saliva or fæces of a healthy individual, and the magisterial dictum of an "expert microscopist" that these minute organisms are entirely harmless. That there are many widely distributed forms (species?) which are ordinarily harmless cannot be questioned, but that pathogenic bacteria exist, either as distinct species or as physiological varieties (Pasteur) of common forms, is now definitely proven.

No apology, then, is needed for a study of this nature, the object of which is to place upon record photographic representations of the common bacterial organisms found in the bodies of healthy individuals, and some observations relating to their physiological properties and the best methods of studying them.

It is evident that a precise knowledge of the morphology and development—life-history—of these common forms is an essential prerequisite to the recognition of unusual forms, and to the enlightened study of the possible relation of such forms to any particular diseases with which they may be found associated.

I call attention, however, *en passant*, to the fact that recent researches indicate that too much importance has heretofore been attached to morphological distinctions, and that not only may the same organism present distinct morphological peculiarities in different stages of its development, but that during the same stage differences in size, if not in form, may result from conditions relating to the environment, temperature, composition and reaction of medium, presence or absence of oxygen, etc. On the other

[3] In the bibliography compiled by Magnin (The Bacteria: Little, Brown & Co., Boston, 1880) and added to by myself, but which can by no means be considered complete, the references from 1830–40 are seven, from 1840–50, twelve, from 1850–60, seventeen, from 1860–70, sixty-three, from 1870–80 above three hundred and fifty; and in the second volume, just published, of the Index Catalogue of the Library of the Surgeon General's Office, four closely printed pages are required for the references relating to "*Charbon*" alone.

hand, organisms morphologically undistinguishable from each other may possess very different physiological properties.

The researches of some of the pioneers in this field of investigation, and especially the discovery by Davaine of a bacillus in the blood of anthrax, and of Obermeier of a spirillum in that of relapsing fever led many to anticipate that organisms morphologically distinct might eventually be discovered for each specific disease. This expectation has not been realized, and the germ-theory has been vigorously attacked by conservative opponents, who have properly pointed out the morphological identity of *Bacillus anthracis* and *B. subtilis*, and of *Spirochœte Obermeieri* and *S. plicatile* which is sometimes found in the mouth of healthy individuals. This argument has, however, lost its force, and the common and usually harmless bacteria around us have acquired a new importance, since it has been shown by Pasteur,[4] Buchner,[5] Greenfield,[6] Grawitz,[7] and others, that by special methods of cultivation pathogenic varieties may be developed from harmless organisms, and that by certain treatment deadly bacteria may so far lose their virulence as to produce only a mild, although protective, form of disease.

In a recent study[8] of "a fatal form of septicæmia in the rabbit, produced by the subcutaneous injection of human saliva," I have obtained experimental evidence pointing in the same direction.

What is the rôle of those micro-organisms which are constantly present in the alimentary canal of men and animals? The fact that they are parasites does not exclude the possibility of their playing an important physiological rôle in the animal economy.

I am not speaking of accidental and occasional parasites, but of those which have probably been the commensals of man, and of the inferior animals frequented by them, from the earliest times. It can hardly be possible that in the process of evolution the presence of these parasites has had no influence upon the host; or to go no farther back, that, in the gradual change from the mode

4 "De l'atténuation du virus du choléra des poules". C. R. Ac. des Sci., XCL, p. 373, 380.

5 "Ueber die experimentelle Erzeugung des Milzbrand Contagiums aus den Heupilzen". Munchen, 1880.

6 "Further Investigations on Anthrax and allied diseases in Man and Animals." Brown lectures I-V, London Lancet, 1880, pp. 965–966, 1881, pp. 3–4, 91–94, 163–164.

7 "Ueber Schimmel Vegetationen in thierschen Organismus". Virch. Archiv, Bd. 81 (1880). p. 355.

8 "A fatal form of Septicæmia in the Rabbit produced by the subcutaneous Injection of Human Saliva." Bulletin Nat. Board of Health, April 30, 1881.

of life and habits of a nomadic savage to that of a civilized man, the change in environment has had no modifying effect upon these micro-organisms, which laboratory experiments show to be so susceptible to changes in temperature and in the composition of the medium in which they are placed.

Reference is made to the accounts given by various authors (Remak, Miquel, Robin, Neidhardt, Hyde Salter, Hallier, Kolliker, Farlie Clarke, Billroth, Koch) of the micro-organisms commonly found in the human mouth, and especial attention is called to the recent papers of Butlin[9] and Rappin.[10]

METHODS OF RESEARCH.

Collecting.—I have found the following to be the most satisfactory method of collecting bacteria for examination with high powers and for photography.

The slightest possible smear of the material to be examined is allowed to dry upon a thin glass cover, and to secure a sufficiently thin and uniform layer, it is usually best to spread it while moist with the end of a glass slide. Material is obtained from the mouth by scraping the surface of the tongue, or of the teeth, with a clean instrument, from the rectum upon tissue paper from the closet, from the female vagina by a speculum or digital examination, and from the mouth of the male urethra by applying a thin cover directly to the mucous membrane at the orifice of the canal.

Staining.— A five cent bottle of aniline violet ink furnishes an ample supply of staining-fluid of the best quality. Two or three drops of this placed upon the thin cover will very quickly — one to three minutes — give to the bacterial organisms attached to its surface a deep violet color. The cover is then to be washed by a gentle stream of pure water, and is ready for immediate examination, or may be mounted for permanent preservation over a shallow cell containing a solution of potassium acetate (Koch's method), carbolic acid water (2–5 per cent.), camphor water, or simply distilled water.

To make satisfactory photographs of the smallest bacteria it is necessary to use a staining fluid which will give stronger photographic contrast, as the violet is transparent for the actinic rays.

[9] "On the nature of the Fur on the Tongue." Proc. Royal Soc., London, Vol. XXVIII, p. 484.

[10] "Des Bactéries de la Bouche." Thése de Paris, No. 144, April, 1881.

I have employed for this purpose aniline brown (recommended by Koch) or iodine solution (iodine 2–5 grs., potassium iodide q. s. to dissolve, distilled water 100 grains). It must be remembered that aniline solutions often contain a granular precipitate which might be mistaken by a novice for deeply colored micrococci.

Photographing.— I cannot here give a detailed account of the technique of the art of photo-micrography, but will simply say that there are many difficulties to overcome and that the best results can only be obtained by the use of first-class objectives of high power, and by skilful manipulation in the preparation of slides and projection of a well-defined image, supplemented by a sufficient knowledge of the technique of photography to ensure the making of well-timed, well-developed and properly intensified negatives. For one who has not the services of a practical photographer at his command, the dry-plate process offers many advantages.

Culture experiments.—A knowledge of the life-histories and physiological properties of the various vegetable parasites which infest the human body can only be obtained by well-devised and carefully conducted culture experiments. This method of research is still in its infancy, but it has already given valuable results, and must doubtless be our main reliance for the advancement of science in this direction. My own experiments have thus far been made chiefly with a view to testing methods and are preliminary to more extended studies which I hope to make in the future.

Culture-cells in which a drop of fluid — aqueous-humour, etc.— containing organisms to be observed, is in contact with the thin glass cover and surrounded by a limited quantity of air, are useful and convenient for certain purposes, especially for the continuous study of successive stages in the development — life-history— of bacterial organisms. But the method of Pasteur — cultivation in gross in sterilized fluids contained in glass-flasks — offers decided advantages so far as the isolation, preservation and cultivation of special forms, and the exclusion of atmospheric germs are concerned; and, also, because the considerable quantity of fluid used gives material for physiological experiments—injections into animals, etc.

The method which I have found most satisfactory after a considerable number of experiments with various forms of apparatus,

is a modification of that of Pasteur. The culture-flasks are made from glass-tubing of about $\frac{1}{4}$ inch diameter. . . . .

I have found it much easier to make new tubes than to clean old ones; I therefore throw them away when they have been once used. After blowing the bulb, the lower extremity is drawn out into a capillary tube and hermetically sealed in the flame. In this condition the flask, which is already sterilized by heat, may of course be preserved, indefinitely free from contamination by atmospheric germs.

To introduce a liquid into the flask, break off the sealed extremity of the capillary tube, heat the bulb slightly and plunge the end of the tube beneath the surface of the liquid. . . .

I have found it best not to trust to the sterilization of the culture-liquid before its introduction into the flasks, and am in the habit of filling a considerable number of these at one time with filtered chicken-*bouillon*, Cohn's fluid, hay-infusion, or whatever culture-fluid I may desire to use. After again hermetically sealing the capillary extremity of the tubes, sterilization of the liquid contents is effected by heat.

This is accomplished by placing the flasks in a bath of oil, melted paraffine, or concentrated salt-solution, and maintaining them at a temperature of about 105° C. for an hour or more. Occasionally a flask which has an exceptionally thin bulb will explode, and care must be taken by the operator that the hot oil is not thrown into his face by such an accident. This possibility makes it desirable that a bath should be used having a fixed boiling point, not too high, and which consequently does not require watching. I have found a concentrated salt-solution to fulfil this requirement. After sterilizing, the flasks are washed to remove the salt-solution from their surface. They are then placed in a culture-oven, kept at a temperature of 95°–100° Fah. (36°–38° C.), for three or four days, to test the success of the previous operation — sterilization. If the liquid contents remain transparent, and no mycoderma has formed upon the surface during this time, the flasks may be put aside for future use and can be preserved indefinitely.

To inoculate the liquid contained in one of these flasks with organisms from any source, the extremity of the tube is broken off with forceps, the bulb being dependent, and by the application

of heat — the heat of the hand is usually sufficient — enough air is forced out to cause a little fluid to be drawn into the tube upon immersing its extremity in the liquid and allowing the air in the bulb to again contract by cooling. A little experience will enable the operator to inoculate one tube from another, to introduce a minute quantity of blood containing organisms directly from the veins of a living animal, etc., without any danger of contamination by atmospheric germs. No other method with which I am familiar offers such security as to sterilization of the culture-liquid and exclusion of foreign germs. . . . . . Small quantities of fluid are conveniently obtained from time to time for microscopical examination by breaking off the end of the tube, forcing out a little of the contents upon a glass slide, and immediately sealing the extremity again in the flame of a lamp.

Another form of apparatus which I have found very useful is that of Lister. In the apparatus as described by Lister, a conical wine-glass contains the culture-liquid and this is covered by a circular glass plate, the whole being protected from dust by a bell-jar which rests upon a ground-glass plate. When proper precautions are taken a sterilized liquid may be kept in this apparatus for any length of time without undergoing perceptible change. . . . .

The most conspicuous vegetable organism found in the healthy human mouth, and the one which will usually first attract attention upon microscopical examination with low powers, is the well-known *Leptothrix buccalis*, Robin. This I have never failed to find in greater or less abundance in material scraped from the surface of the tongue, or in accumulations dislodged from between the teeth. Often it is found in tufts and masses which indicate a vigorous and rapid growth, and again it may only occur in the form of short rods sparsely intermingled with the normal histological elements of the saliva. But in this case it is probable that a careful search would reveal the presence in the mouth of the microscopic plantations and garden-beds from which these fragments were detached. As might be expected, those who make frequent use of the tooth-brush leave less soil upon the surface and in the interstices of the teeth for the growth of this and other vegetable parasites. No amount of care, however, will keep the mouth entirely free from them, and the observations of Butlin (*l. c.*) show that the fur upon the tongue, which is rarely entirely absent even in healthy individuals, is in great part made up of this and other vegetable parasites. . . .

A form of culture apparatus is described and figured which is designed to imitate the conditions found in the human mouth, viz.: a constant supply of pabulum and free access of oxygen. This has been successfuly used for cultivating *Leptothrix buccalis* and other organisms found in saliva. . . . .

The recorded observations of microscopists show that nearly every common bacterial organism known is occasionally found in the human mouth.

This is no more than we should expect, as the germs of these various organisms are widely distributed in the atmosphere and must be deposited upon the moist mucous membrane during inspiration. Their development here will of course depend upon whether the conditions are favorable or otherwise. As these conditions vary within certain limits, we naturally find, at different times and in different individuals, a variety of organisms present in the buccal secretions, differing from those common forms which observations made at distant points show to be constantly present under normal conditions.

Among the varying conditions found in the mouths of individuals considered healthy may be mentioned a greater or less abundant flow of saliva, a difference as to the reaction of this fluid, the presence of decayed teeth, various habits as to food, drink, use of tobacco, etc., etc.

When engaged in the microscopical examination of foul gutter-water and in culture experiments with various putrefying organic substances in New Orleans, during the autumn of 1880, I not infrequently found nearly every organism in my own mouth which was present in the putrefying liquids under examination, including *Bacterium termo*, *Bacillus subtilis*, *Spirillum undula*, and a variety of minute spherical and rod-like forms difficult to classify except under the general heading of micrococci and bacteria. . . . .

Another organism which I have frequently found in specimens of saliva from healthy mouths is a species of *Sarcina*, perhaps identical with *S. ventriculi*. . . . . .

I have frequently observed little clusters of this sarcina-like organism attached to the surface of epithelial-cells in my own saliva and in that of others, but to obtain it in abundance I have found it necessary to resort to culture-experiments. . . . .

The micrococcus found in the human mouth possesses an especial interest, because of its abundant and constant presence, and because it has been shown to possess pathogenic properties

when injected beneath the skin of a rabbit. This fact has been brought to light by recent experiments made independently by Pasteur[11] in France and by myself in this country,[12] since confirmed by other observers.[13] . . . .

The fact that this micrococcus is the most common organism found in the human mouth, and that it has been described by several observers at distant points, may seem difficult to reconcile with the fact, recently developed, that to its presence is due the *exceptional* virulence of the saliva of certain individuals. It accords, however, with the results of recent investigations, which, as already stated in the introduction to this paper, indicate that pathogenic organisms may differ greatly as to their virulent properties as the result of different conditions relating to their environment acting upon successive generations.

My observations lead me to believe that, having a suitable medium, a proper temperature, and a sufficient supply of oxygen, the development or intensification of pathogenic properties depends to a great extent upon an abundant and constantly renewed supply of pabulum.

Now this is a condition which differs greatly in the mouths of different individuals. In my own case there is and has been from my earliest recollection, a very copious secretion of saliva. This, according to my view, may account for the exceptional virulence which my experiments show it to possess and is in conformity with the law of natural selection.

Rapid multiplication is, I infer, an evidence of vigor. Now it is evident that in a natural culture apparatus like the human mouth, the rapid flow of saliva by which contained organisms are constantly washed away will have a tendency to sort out those which develop slowly from those which develop rapidly, and that the former will tend to disappear entirely, while the latter by virtue of their rapid multiplication will survive and the tendency will be constantly in the direction of a further development of this property of rapid multiplication. My culture experiments have shown me that, in fact, this particular micrococcus does multiply with great rapidity, and that by virtue of this quality it has for a time the

[11] Comptes rendus, Ac. d. sc., 1881, XCII, p. 159.
[12] Bulletin National Board of Health, April 30, 1881.
[13] Vulpian. Bull. de l'Acad. de Med., March 29, 1881.

precedence over *Bacterium termo*, the presence of which in any considerable numbers seems to be fatal to it.

This rapidity of multiplication is shown by the fact that the subcutaneous injection—in the rabbit—of a minute quantity of material containing it results within twenty-four to forty-eight hours in the development of an infinite number of micrococci in the body of the animal. In my culture-flasks also, a minute drop of the blood of an infected rabbit gives rise within a few hours to the development of such a number of micrococci that the fluid contents of the flask are invaded throughout, and the pabulum needed for a continued development is exhausted.

I suspect, then, that this is the simple explanation of the phenomenon in question—exceptional virulence. And I am inclined to think that the *modus operandi* of the action of pathogenic organisms is also to be explained by the possession of this capacity for rapid multiplication.

Nature has placed, or, in other words, evolution has developed, in the living tissues of animals, a resisting power against the encroachments of bacterial organisms invading and surrounding them, which is sufficient for ordinary emergencies. But when the vital resistance of the tissues is reduced, on the one hand, by wasting sickness, profuse discharges, etc., or, on the other, the vital activity of the invading parasitic organism is increased, the balance of power rests with the infinitesimal but potent micrococcus. . . . .

The possibility is suggested that it is the office of the white blood corpuscles to pick up and destroy bacterial organisms which find their way into the blood. . . . .

Reference has already been made to the common bacterial organisms found in normal human fæces at the moment of their being discharged from the rectum. My photo-micrographs tell the story of the abundance and variety of these organisms, but the present state of knowledge does not admit of an attempt to determine their physiological rôle in the human economy. That their constant presence in the alimentary tract is a fact without import, it is difficult to believe in view of their demonstrated capacity for breaking up complex organic substances external to the body in the process of their growth and functional activity. . . .

By gently separating the lips of the male urethra and applying

a thin glass cover to the moist mucous membrane, good specimens are readily obtained of the organisms commonly found in this locality.

The researches of Lister and others and my own experiments, shortly to be detailed, indicate that the healthy human bladder is free from parasitic vegetable organisms, and it is probable that those organisms found at the extremity of the urethral canal, being *aerobic*, do not extend any considerable distance beyond the orifice. Lister has shown that urine drawn from the healthy bladder with proper precautions may be kept indefinitely; and Pasteur as long ago as 1862 showed that the alkaline fermentation of urine is due to the presence of an organism, *Micrococcus ureæ*, Cohn.

The following experiments are reported here as relating to the rôle of this micrococcus, which, notwithstanding the researches of Pasteur, Lister and others, is not, perhaps, generally admitted by chemists and physiologists to be *un fait établi.*

Having repeatedly demonstrated the presence of micrococci at the mouth of the male urethra and knowing that Lister's experiments indicate that urine as contained in the healthy bladder is free from bacterial contamination, it occurred to me that in passing urine from a full bladder the first portion of the stream might wash away detached epithelial cells and bacterial organisms and that the last portion, being received in a sterilized flask, would give evidence of freedom from these organisms by remaining unchanged. Accordingly, I made the following *experiment:*

Baltimore, Md., June 25, 1881. Two bell-shaped glass cups were sterilized in the flame of a Bunsen burner and placed under clean bell-jars (Lister's apparatus). A small quantity of urine was then passed into No. 1 from the first portion of the flow and in No. 2 from the last, removing and replacing the bell-jars as expeditiously as possible.

Result. June 30. No. 1 contains a considerable deposit, is turbid, and is decidedly alkaline. No. 2 remains perfectly transparent, has no sedimentary deposit and is acid. No. 1 contains an abundance of micrococci, and No. 2 is free from organisms. A single drop taken up from the bottom of No. 1, by means of a pipette, was allowed to fall in No. 2. The following day No. 2 was turbid, had an alkaline reaction and contained an abundance of *Micrococcus ureæ*. This experiment cannot be expected to succeed in every instance as the complete washing away of organisms by

the first portion of the stream may not always occur, and it is possible that the previous passage of urine may have washed out the urethra and that consequently the first portion passed would be free from organisms while the last might be contaminated by the detachment of epithelium in which micrococci were embedded as seen in my photographs. Some such explanation is necessary to account for the result obtained in the following experiment.

Experiment No. 2. Baltimore, Md., Aug. 1, 1881. The above experiment was repeated. Urine was again passed into two sterilized glass cups, arranged as before and observing the same precautions.

Result. Aug. 11. No. 1 remains acid and transparent in the upper portion but the lower third is occupied by a loose finely granular deposit, such as is often seen in fresh urine immediately after cooling. No. 2 has an alkaline reaction, a film of urate of ammonia on the surface and an abundance of *Micrococcus ureæ* in the copious deposit at the bottom of the cup.

Experiment No. 3. Baltimore, Md., Aug. 1, 1881. Four sterilized cups were prepared as in the preceding experiments and into each was passed a small quantity of urine after first taking the precaution of disinfecting the extremity of the urethra. This was accomplished by the liberal use of a three per cent. solution of carbolic acid, which was applied by means of a pledget of asbestos held by slender forceps. The asbestos was first sterilized by heat and then being dipped in the disinfecting solution was repeatedly and thoroughly applied to the mucous membrane to the depth of half an inch or a little more.

Result. Five days after (Aug. 6) the urine in all of the vessels remained transparent. At this date No. 3 was inoculated with organisms from the mouth of the urethra. This was done by twisting around in the orifice of the urethra a small ball of asbestos previously sterilized by heat, which was then dropped into the cup, containing urine, the bell-jar being removed for an instant only for this purpose. Five days later the contents of the four cups were carefully examined. Nos. 1, 2, and 4 remained transparent and acid. No. 3 was alkaline and contained an abundance of *Micrococcus ureæ*. . . .

A STUDY OF BLOOD DURING A PROLONGED FAST. By LESTER CURTIS, of Chicago, Ill.

ON Saturday, the 28th of last May, Mr. John Griscom began a long fast in Chicago, which was to continue for forty-five days. Before the fast began I was invited by the managers to make any observations of Mr. Griscom, during the fast, that I wished. After convincing myself that the fast was to be conducted honestly and in a scientific spirit, I accepted the invitation, and chose the blood as a subject of study. I examined the blood with the microscope from day to day, measured the corpuscles and counted their number in a measured volume of blood.

The first examination was made shortly after noon, just after he ate his last meal. It indicated that the man was in an excellent condition of health; the vessels seemed full of blood which flowed freely whenever a puncture was made. The red corpuscles were abundant, their color was bright, they had a regular and smooth outline, seemed firm and solid, and were of the usual size. I made measurements of several and found the average diameter to be about $\frac{1}{3100}$ of an inch.

The next examination was made Tuesday the 31st, at the beginning of the fourth day; the principal change noticed at this time was that the corpuscles were paler than before and did not have the same firm appearance that they then had.

On the next day the change had progressed still further, and two sorts of corpuscles could be distinguished, one pale and large, the other deeper in color and contracted.

The first of these were exceedingly pale, some having so little color as to be almost invisible. They appeared soft and sticky, and spread out over the slide, a little like soft pitch. If they met any obstacle when floating along they would bend around it in somewhat the same way as any soft substance floating in water would bend around a snag. Many were seen adhering to the slide and were not easily detached by the other corpuscles coming in contact with them. They also differed somewhat from the usual shape. In place of the usual uniform concavity, many of them had a rounded rim with an abrupt descent to a flat floor. Altogether they had a limp and wilted look. Their size, also, was

slightly diminished. The average diameter of a number was about $\frac{1}{4000}$ of an inch.

The other sort of red corpuscles were much deeper in color than those just described. They seemed to be deeper in color and less transparent than even the normal corpuscles. They were covered with nodules in the shape of blunted cones and did not show the usual concavity in the centre. They retained their shape with a great deal of firmness when meeting with an obstacle, more so than an ordinary healthy corpuscle. Altogether they appeared as though they had been acted upon by an astringent. They were also much smaller than the first variety; the average diameter of a number of them being $\frac{1}{4400}$ of an inch.

The next evening, Thursday, the fifth day, the soft pale corpuscles had disappeared, leaving only the second variety. These also lost much of their nodular appearance and seemed to be spread out and to be of a larger size than before. The general appearance of the blood was more like that of healthy blood, although it had a wilted look, and the corpuscles in the rouleaux adhered together a little too closely; the line of division between them instead of being a clean deep furrow, was only an irregular trace. Many of the corpuscles stuck to the slide in an unusual manner. The corpuscles continued to be small. The average of ten corpuscles in one field, taken as they came, was $\frac{1}{3500}$ of an inch. This was rather above the average of another field containing thirty corpuscles which I traced carefully, but did not measure, except by comparing with other fields. About this time also, irregularities began to appear in the shape of the corpuscles; many were elongated, some had an outline like a lemon, being pointed at each end, some were club-shaped. Many corpuscles stuck to the slide at one point and floating along in the current would draw out a tail. The corpuscles would sometimes become loosened from this attachment, but the tail would be only partially retracted and would remain a permanent appendage of the corpuscle. Many corpuscles were seen with this tail.

In a few days the large colorless soft corpuscles began to reappear and from this time on, continued to be present in greater or less numbers. Sometimes they almost disappeared; at other times they were found in abundance. The bodies with the thickened rim and the flat floored concavity were also found in increasing num-

bers. As the time progressed the peculiarities of these last corpuscles became more and more marked. Some of the corpuscles were very limp. When one edge happened to rest on anything which raised it above the level of the other side, it would often fold up leaving a crease across it, and the rim would often roll over towards the centre as though the body were composed of some soft heavy substance. Occasionally a pale red corpuscle was seen with an eminence shaped like a cone with a rounded top, projecting from its surface. This eminence was colored rather more deeply than an ordinary healthy blood corpuscle and formed a striking contrast with the pale surface of the remainder of the body. These corpuscles, however, were more abundant later on.

About the eighth or ninth day I began to notice a number of small colored bodies looking like red corpuscles. Some of these were as small as $\frac{1}{5300}$ of an inch, and there were many only slightly larger than this. The size of all the corpuscles at this time was small. The average of several fair-looking ones, lying next one another in the same field, was $\frac{1}{3700}$ of an inch.

From this time the extremely small corpuscles, if I may be allowed to call them such, continued to increase in number and to diminish in size. On the 12th of June, the sixteenth day of the fast, I noticed one which was only the $\frac{1}{1600}$ of an inch in diameter. A day or two after this I sketched two groups; one consisting of three, and the other of four, red corpuscles. The measurements of the first of these were $\frac{1}{3000}$, $\frac{1}{5500}$, and $\frac{1}{12000}$ of an inch. The largest of these corpuscles was very pale and soft. The second group measured $\frac{1}{3200}$ of an inch for two of the corpuscles, $\frac{1}{5500}$ for another, and $\frac{1}{8000}$ for the fourth. Corpuscle-like bodies, even smaller than any I have mentioned, were also seen, some as small as $\frac{1}{20000}$ of an inch. Those down to the size of $\frac{1}{5000}$ or $\frac{1}{6000}$ of an inch resembled ordinary red corpuscles very closely; some were nodulated or had the chestnut burr appearance, but many resembled the red corpuscles, not only in color, as did these last, but they had the biconcave shape, and all the other appearances of an ordinary red corpuscle. The smaller bodies were either globular or lenticular in shape, but they had the same color and refracted light in the same way as the ordinary corpuscles. I also noticed that these small corpuscle-like bodies were usually found near a larger red corpuscle, but not a very large one. Often a medium

sized red corpuscle and one of the smaller ones were seen lying next one another, sometimes the smaller on the top of the other, or *vice versa*. The club-shaped corpuscles, mentioned before, again became prominent. They usually consisted of two ovals joined by a short thick neck. Several times corpuscles were seen having bud-like processes. Sometimes I saw red corpuscles with a tail-like projection pointing towards one of the small bodies.

On the evening of the third of July, the 36th day of the fast, I noticed a corpuscle which looked like an exclamation point with the dot attached. This attachment grew longer and thinner until finally it ruptured, and the corpuscle divided into two portions. The smaller of these showed an indication of a tail, exceedingly faint, which was afterwards lost to sight, but was not seen to retract. In the larger one the tail retracted partly, but there still remained traces of it for an hour or more while I watched it. When I first noticed the corpuscle in the act of dividing I did not see any evidence of a concavity; it was convex in every direction, but a few minutes after the division the larger portion became flatter and more nearly circular, and soon a concavity appeared, and then it could not have been distinguished from many other corpuscles in the same field. On this evening, and at other times, I saw other corpuscles that seemed to be in the act of dividing, but I never saw any others actually passing through the process.

From this time on for several days the corpuscles changed rapidly for the worse. Many large pale ones were seen, some having the colored eminences above described projecting from their surfaces. Sometimes two or three of these eminences were seen projecting from the same corpuscle. Many of the bodies with the thick rim were seen, some with the centre so thin and transparent, and with the descent so abrupt that it seemed as though a hole had been cut out of the body with a punch. In one instance I saw a corpuscle with three such depressions. Some of the corpuscles had the appearance of a partially emptied bag floating in the serum of the blood. If one of these happened to rest on its edge this lower part would flatten out and the upper portions would fold and wrinkle into many curious shapes. The most of the corpuscles that retained any color appeared contracted and shrivelled. Before long the corpuscles began to be ragged and distorted, some appeared to be broken into fragments. I noticed one, triangular in

shape, with one rounded edge, looking as though it had been cut out of a corpuscle by two incisions, as one would cut out a piece of pie. At this time Mr. Griscom showed evidences of weakened circulation. One evening I noticed marked dichrotism of the pulse. On referring to the sphygmographic tracings made the same day, the same appearance was seen. When sitting or standing he experienced a sensation of giddiness and a feeling of numbness and tingling in his hands and feet, and described a feeling as though a tight band were drawn around his head. This was relieved by lying down.

On the morning of July 4 he rose from his bed suddenly and fainted away. On the evening of July 5, thirty-ninth day of the fast, there was scarcely a normal corpuscle to be seen. The evidence of weakened circulation was more marked, and his attendants began to be alarmed; even he became nervous although he strove to conceal the feeling.

On the afternoon of July 6, the fortieth day of his fast, he took an excursion for about two hours and a half on the Lake. On his return a most remarkable change was seen in the appearance of the blood. The ragged and broken corpuscles, and the very pale ones, which had been so abundant, had almost all disappeared, and all the corpuscles had become smooth in outline and of a clear bright color. Indeed, it would be difficult to tell in what respect these corpuscles differed from those of any healthy man, except perhaps in size. They continued to be abnormally small; the average of one count being about $\frac{1}{3500}$ of an inch in diameter, and no corpuscle being found larger than $\frac{1}{3430}$ of an inch. The number of the corpuscles, however, dropped very considerably. I counted 3,200,000 in a cubic millimetre in place of 4,200,000 on the preceding day.

After this the corpuscles again retrograded. They became soft and pale, and regained the sticky character which they had partially lost after the excursion on the Lake, but they never again looked as bad as they did before that time.

The number of blood corpuscles in a cubic millimetre of blood was carefully estimated on forty different days, thirty-eight times during the fast and twice after its completion.

On account of the imperfections of the apparatus which I at first attempted to use, I failed to get a satisfactory count of the

corpuscles until the beginning of the fourth day of the fast. At that time I estimated the number of the corpuscles in a cubic millimetre at 4,320,000. When we remember that the number of corpuscles in a cubic millimetre in health is about 5,000,000, the number found would be about what we might reasonably expect after a fast of three days. The next day the number was 4,485,000, slightly higher than the day before, but not change enough to attract much attention.

The next day, however, the number suddenly dropped to 2,370,000 a most startling change to me, and one which led me to examine my methods carefully, to detect any possible source of error in the count. It will be noticed that this drop in the number of the corpuscles corresponds with the first disappearance of the pale corpuscles. The next day no count was made, but the day after, the eighth day of the fast, the number was 4,860,000, higher than it had been at any time. The next day the number was not counted, but on the tenth day, June 6, the number again dropped to 3,260,000; this was followed the next day by another rise to 4,720,000. The dropping in number had not been as low as in the former case, and the subsequent rise was not as high. For the two or three following days the fluctuation in the number of the corpuscles was small. The numbers were, on June 8, the twelfth day, 3,790,000; on the thirteenth day 4,480,000; on the fourteenth day 4,210,000. But on June 11, the fifteenth day of the fast, the number fell to 2,800,000. There was no count made for the next two days, but on June 14, the eighteenth day, the number rose to 5,790,000; on the nineteenth day they were 6,770,000; on the twentieth day they had begun to fall and were 6,500,000; on the twenty-first day, they were 5,600,000, and on the twenty-second day of the fast, June 18, they fell to 2,100,000, the lowest during the whole fast. This day Mr. Griscom felt quite ill. He complained of flatulence and pain in his stomach, and took an enema of warm water which relieved him, and caused an evacuation of his bowels.

The next day, the twenty-third day, the number rose to 5,460,000; on the twenty-fourth day, the number was 5,420,000, the next day, the twenty-fifth day, the number was 3,920,000, the twenty-sixth day it was 4,160,000; the twenty-seventh day, 2,540,000.

The numbers succeeding this were more uniform, being,

on the 28th day, . . .	3,130,000
" " 29th, ...	3,180,000
" " 30th, ...	3,180,000
" " 31st, ...	3,360,000
" " 32d, ...	4,420,000 (?)[1]
" " 33d, ...	3,660,000
" " 34th, ...	3,900,000
" " 35th, ...	3,700,000
" " 36th, ...	3,810,000
" " 37th, ...	3,520,000
" " 38th, ...	4,080,000
" " 39th, ...	4,200,000

On the fortieth day he made his excursion on the Lake. It will be remembered that a very great change was noticed in the blood on his return; his corpuscles numbered

on the 40th day, . . .	3,020,000[2]
" " 41st, ...	3,390,000
" " 42d, ...	3,590,000
" " 43d, ...	3,490,000
" " 44th, ...	3,150,000
" " 45th, ...	5,390,000[3]
the next day after he broke his fast,	5,860,000
the next day, ...	5,790,000

These figures differ in many ways from what we would expect, but, if we look at them closely, we shall see that they are not entirely destitute of symmetry. Notice that the greatest drop in the number of the corpuscles was on the 6th, 10th, 15th, 22d, 27th, 37th, 40th and 44th days, giving intervals of 6, 4, 5, 7, 5, 10, 3 and 4 days and pointing to the opinion that there may be a certain limited duration of the red corpuscles, not quite uniform, and determined to a certain extent by circumstances, but shorter than

[1] This number is perhaps not quite correct.

[2] The lowest they had been for two weeks.

[3] This blood was taken just before he broke his fast. He had drank no water for the twenty-four hours preceding.

we have supposed. The drop on the thirty-seventh day was very slight and did not clear away all the old corpuscles. If we take in this time from the twenty-seventh to the fortieth day, we have a period of two weeks. During this time the corpuscles were at their worst, and Mr. Griscom was at his worst also.

Notice again, that just before a drop there is always a rise, sometimes extending over a period of several days, as though the corpuscles were breaking up preparatory to going to pieces altogether.

Again, after every drop the corpuscles looked better than they did just before, and every drop was succeeded by a rise in very nearly the same ratio as the preceding fall.

It will be noticed, also, that on the last day, Mr. Griscom drank no water, and the number ran very high, due perhaps, to the greater concentration of the blood. This concentration of the blood may have something to do with the variation in the number of the corpuscles.

Allow me here to call attention to certain bodies which I have found in all human blood that I have examined. They are minute granules which can be seen with a good high-power glass without the addition of any reagent, but they are best seen after staining. If we place a drop of carmine staining fluid at the upper edge of the cover-glass, while studying a drop of fresh blood, with the microscope inclined, there will soon be seen bright red points sliding across the field, long before any other evidence of staining appears. As the staining fluid comes down further, these bodies increase in number until, finally, when the field of the microscope has been entirely traversed by the fluid, they are countless. Under a magnifying power of from 1200 to 1500 diameters, they appear as minute round bodies of varying size, which I have estimated as averaging about $\frac{1}{20000}$ of an inch in diameter. They are highly refractile, appearing as bright red points with a black rim which varies in width as the focus is changed; when they are slightly beyond the focus, the red point disappears, and they look like black dots. Dr. Osler and others have described something similar in the blood of the lower animals, but their descriptions do not agree in all points with what I have seen.

I have examined the blood of persons of all ages, and in all conditions of health and, with one exception, have never failed to

find these bodies. I have also found them in other fluids of the body and in cows' milk, though not very abundant.

In my first examination of Mr. Griscom's blood I found them in great numbers and continued to look for them during the whole fast. In a few days they were less abundant, and then they disappeared and returned again, but on the eighth day of the fast they disappeared entirely, or only an occasional one was found. They remained absent until June 27, the twenty-fourth day of the fast, when I began to notice a few very pale ones. They increased in number and in refractive power and in capacity to receive staining, until after a few days, they assumed their natural characters, but they were not abundant until after the close of the fast, when they at once assumed their old appearance.

The white corpuscles also attracted my attention during these observations. On the first day of the fast I saw nothing specially peculiar about them. Soon, however, I began to notice bodies resembling white corpuscles, only larger and more distinctly granular. They continued to increase in size and were not long in attaining a diameter exceeding $\frac{1}{2000}$ of an inch. They were composed of a large number of spherules of small size exceedingly difficult to measure. The bodies often had an active amœboid movement. During the movement the granules seemed to flow out into the protruding portion, in a kind of stream. The granules in the corpuscles were usually still, but sometimes they had a swarming sort of motion. I have watched one single granule move for a considerable distance through the body before I lost sight of it. The large bodies usually had one or more places destitute of granules, which looked like nuclei; but they did not stain with carmine and appeared to me to be a vacancy of granules rather than nuclei. They were evidently depressions, and by careful focussing the floor appeared to be slightly uneven. Later on I saw the granules apparently leaving the bodies. At this time the free granules that have been mentioned reappeared in the blood. The time when these bodies were most abundant corresponded with the absence of the granules.

A day or two after the completion of the fast I was fortunate enough to discover some of the bodies near by free from granules, and could then see that they had a distinct stroma, apart from the granules.

A few days after the beginning of the fast I noticed some other singular bodies. They were irregular in shape with the general appearance of white blood corpuscles, were faintly granular, and often exceeded $\frac{1}{1000}$ of an inch in diameter. Sometimes they contained dark particles embedded in their substance as though fragments of red blood corpuscles. They became less and less in number with the increase of the first described bodies but never entirely absent.

I noticed some bodies which were stellate in shape, with rays thick at the base, but passing off into long slender filaments which connected with the fibrine threads. They varied in size, but usually were smaller than a white blood corpuscle. They were exceedingly pale and difficult to see, but they had a distinct body, made up of something more than the crossing of fine threads, though appearances something like them were seen which were merely the crossing of threads. These bodies would take a distinct stain from carmine.

There were also other bodies which it is difficult to classify. Several times I saw large colorless disks, sometimes more than $\frac{1}{1000}$ of an inch across. In freshly drawn blood they had a raised rim either smooth or more often slightly fissured at intervals. After a time the fissures extended in every direction dividing the body into a great number of angular pieces. The pieces appeared to be attached to one another, though I am not quite positive about it. These bodies were seen occasionally throughout the whole of the fast.

Small colorless bodies were occasionally seen after the first two or three weeks which resembled oil drops. I did not test these chemically, but I do not think they were oil. They had a refractive power which differed from that of oil; they could not be made to change their shape by pressure as oil could, and under no circumstances would they coalesce. There were some $\frac{1}{5000}$ to $\frac{1}{10000}$ of an inch in diameter though variable. They would not stain with carmine. Other bodies were seen which looked like these only somewhat fainter. They were often collected in masses. They were the palest and most transparent structures that I saw in the blood. I have tried again and again to trace them with the camera lucida, but usually failed, the slight impairment of definition of the prism being sufficient to render them invisible. Often I lost them in looking over a field, and was unable to find

em again. They were présent after their first appearance during e whole of the fast.

After about the fourth week of the fast I occasionally saw a pale obular body, like a sac with a piece cut out of the top. These dies varied from about $\frac{1}{2000}$ to $\frac{1}{4000}$ of an inch in diameter. The spicion has crossed my mind that they were the discolorized re-ains of a red blood corpuscle and that their progenitors were the le corpuscles with the thickened rim, but I am by no means re.

Very often, even early in the fast, I saw bodies of the same color the red corpuscles, embedded in the substance of a granular hite corpuscle. In one instance I saw an unmistakable small d corpuscle with biconcave sides occupying this position.

OME PHENOMENA IN THE CONJUGATION OF ACTINOPHRYS SOL. By J. D. COX, of Cincinnati, Ohio.

IN the latter part of last winter the opportunity occurred of mak-g some consecutive observations upon this rhizopod in an infu-ion in which it appeared in considerable numbers, and some of e phenomena are so curious as to seem worthy of record.

These phenomena more particularly relate to the conjugation of e animalcule; but before describing them, I wish to note one or o points, which have reference only to the general form.

Professor Leidy, in his late work on the Rhizopods, gives his inion that the rays of the *Actinophrys* are simply gelatinous pseu-podia of the same substance as the body, and without any solid-ed skeleton. The evidence for this he finds in the bending of e rays, under the force of a current, like grass in a rivulet. I ve frequently observed this bending, but when it occurs under e influence of a current in the water, or of a passing animalcule of other kind, it has been greatest near the tips of the rays, and emed consistent with a more or less perfect solidity in the parts

near the spherical body. But, what seemed conclusive, I have noted instances in which, by the rush of a *Daphnia* against the *Actinophrys*, the greater mass and impetus of the crustacean have broken the rays near their base, leaving them at right angles to their normal direction.

Again, when the *Actinophrys* passes into a condition, to which I shall refer a little further on, and which I have described as the opaline, the rays, in some instances, show a marked appearance of being dissolved and not simply absorbed or retracted. In some cases, when the animalcule suddenly collapsed, the rays were left as granulated remains of what they were, dissolving in the water separate from the mass of the body, much as if they were spicules of crystal-sugar or some substance of similar solubility.

By this, I do not mean that the ray was altogether of this character, for the gelatinous covering was also made manifest: first, by a rapid retraction, or current, on its surface, by which the more minute objects of its prey were drawn toward the body of the animalcule, and second by a similar outward motion by which the ejecta were carried away from the body.

When, in passing into the opaline condition, the animalcule becomes more transparent, a ring is seen near its centre, which does not correspond to the ordinary appearance of a nucleus, as seen in the infusoria, but has more the appearance of a small inner sphere, such as is seen in the endoskeleton of some of the polycystinæ, and the rays appear to reach through the sarcode of the outer body and to connect with this. I will not speak of this as proved, for the translucence of the animalcule never becomes transparence, and definite assertion would be rash. I will only say that so many phenomena point to the existence of an endoskeleton consisting of two concentric reticulated spheres with rays, partially solidified, but soluble, that I accept this as the probable anatomy of the creature.

The extent to which solidification has gone, and the degree in which it is limited, seem to me to be indicated by the movements of the rays near the contractile vesicle when this expands and collapses. As the vesicle grows large like a great blister on the side of the animalcule, the rays on either side slowly widen their angle, and on the collapse they quickly approach each other, retaining the stiff, rodlike character, and their true line of projection from the centre of the spherical mass.

It has sometimes been stated that the rays of *Actinophrys* cross

each other and grasp the prey; the movement being figured as if the rays were analogous to the spines of *Echinus* and movable from the surface of the body. I have looked for something of this sort with great patience, and have seen the animalcule capture living things, times almost numberless, but have never seen anything like the process described. The radial swinging of the rays when the contractile vesicle collapses is the nearest approach to it, and this, in the case of two Actinophryes in conjugation, will, when the contractile vesicle is near the junction of the two bodies, cause the rays of the two to cross each other on that side. In the capture of prey, however, the process, in all the cases I have observed, is the following:—

If the captured object is minute when compared with the captor, its motion is instantly arrested when it comes in contact with one of the rays. In a moment it slides inward toward the body, when a glairy and true amœboid pseudòpod is extended from the *Actinophrys*, irregular in form, but approximately funnel-shaped. This encloses the prey as in a capsule, which is then slowly drawn into the body of the captor, which assumes its regular outline. In some cases the food is apparently found distasteful, and is ejected again before being completely swallowed.

If the captured object is large, as a rotifer or a vorticella, the process is different. A vorticella will be enveloped by a large capsule, often larger than the body of the *Actinophrys* itself. In this extemporized stomach the food will be seen as a granulated, spherical mass, surrounded by the transparent capsule till digestion is completed, when the ejecta will pass out through the capsule, and the *Actinophrys* will resume its usual form. During the process it will have the general outline of the double form, as seen in conjugation, except that the rays will be seen only on one of the lobes, the other looking like a large, hyaline cell of equal size, but an excrescence on the animalcule.

In the case of carapaced rotifers, or large diatoms, the prey is more completely received into the body of the animal; but this has been so well figured in the ordinary books of reference, that I will not delay upon it. The point I desire especially to note is that in all these processes I have detected no movement of the rays, except such as were plainly mechanical and fully accounted for by the movements of the body in which they were planted. They, together with any connected endoskeleton which may exist,

are forced aside to make room for a diatom, etc., but I could observe nothing akin to spontaneous or voluntary movement.

The powerful stinging or benumbing effect of the rays of *Actinophrys* was exhibited in cases like the following. A *Rotifer vulgaris*, moving across the slide by doubling itself like a measuring worm, came in contact with the animalcule and, being evidently hurt, made violent efforts to get away. In these, the hinder part of the body seemed to have lost its power to take hold, and while the general activity of the body was convulsively increased rather than lessened, its tail constantly slipped back and a rapid series of doublings of the body gave it no headway. If it happened to get beyond the rays, it recovered its normal motions in a few moments. A *Chœtonotus larus*, swimming with its peculiarly strong and graceful motion, struck the rays, and the hinder half of the body became instantly limp and helpless, being utterly without power of motion. The rest of the body seemed strong as usual and kept up the most violent contortions. In this case, also, if the animalcule got away, its powers were restored in a few moments. Another very striking instance was that of the *Trachelocerca olor*. Swimming with its enormously long and swan-like neck extended, it struck one of the rays near the head. The head and part of the neck shrunk like wax melted in a flame, so complete and instantaneous were the shrivelling and loss of form. Cases of similar kinds were constantly occurring, and as the animalcules named are usually larger than the *Actinophrys*, the phenomena impress the observer with the extraordinary power exerted.

CONJUGATION.

The phenomena of conjugation may be considered either as to the exterior form or as to the results. First, as to form. Two individuals approach each other by a slow, sailing motion, as if merely drifting. Sometimes this continues till, the rays having crossed each other, the bodies come in contact and coalesce by the same imperceptibly progressive movement. At other times amœboid pseudopodia are put forth before the contact, and one or more narrow necks connect the two spheres while they are yet separated from each other by one-sixth their diameter.

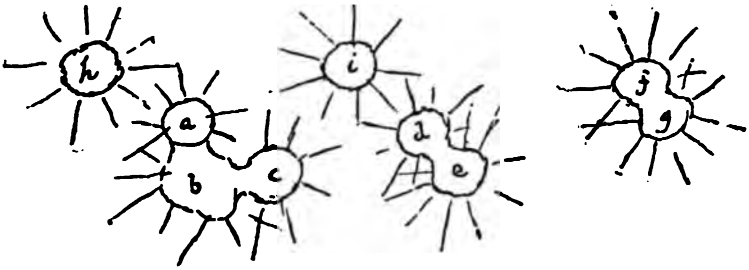
Usually the union proceeds through a dumb-bell shape till the diameter of the connecting part is about two-thirds that of the lobes. In a period varying from a quarter of an hour to several hours the separation begins, the process being now reversed, the

Actinophryes stretching apart till they are connected by a thread almost as fine as the rays. This breaks, part of the thread is absorbed by each, and the two are once more completely distinct. During this process the rays of each lobe radiate from its own centre, and the faint central ring continues visible in each.

Claparède and Lachmann speak of a conjugation of three Actinophryes being observed at once. Leidy mentions it also. In my notes of the series of observation now related, this complex conjugation has occurred between five and six specimens, and in one instance nine were involved, though in this last they did not form one complex mass. A brief description of a few of these cases may be instructive.

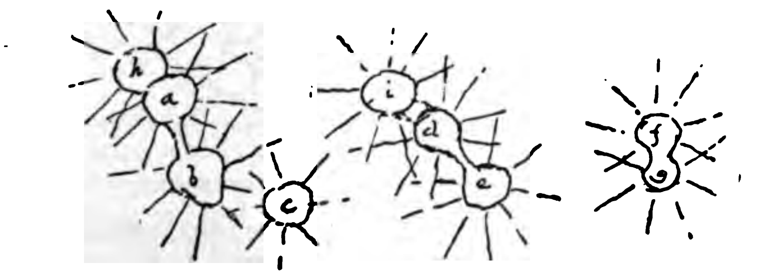
Case 1.— Nine Actinophryes were observed grouped near each other, and when first seen three (fig. 1, *a*, *b*, *c*) were in conjugation in one group, two more (*d*, *e*) in another, two more (*f*, *g*) in a third, and two others (*h*, *i*) were floating separately.

FIG. 1.



That marked *i* slowly approached *d*, *e*, and *d* stretched away from *e* as if attracted by *i*. In a similar way *a* began to leave *b* as if drawn toward *h*, and *c* to move toward *d*, *e*. At the end of the first hour the situation was as shown in fig. 2. In another

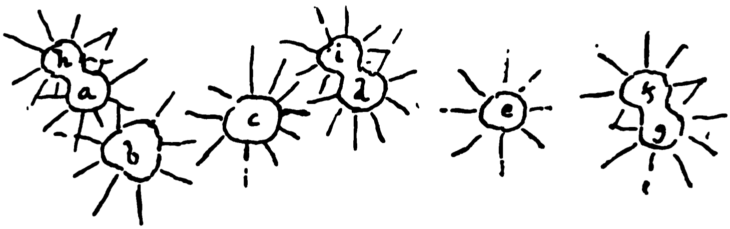
FIG. 2.



half hour conjugation had taken place between *a* and *h*, and be-

tween *d* and *i*; *f*, *g* remained nearly as at first, and *c* and *e* were separate. Fig. 3 shows the general position at this time. An

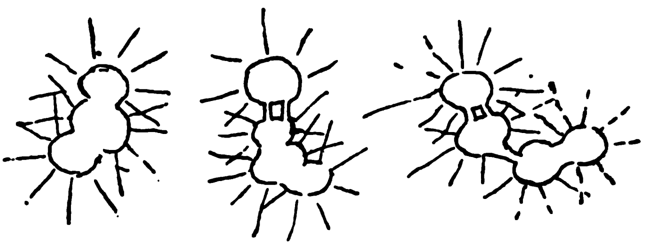
FIG. 3.



hour later, *i* drifting toward *f*, *g*, that pair separated, *f* approaching *e*. So, *c* approaching *d*, *i*, they also separated, as did *h*, *a*. The whole nine were now single again, and the lateness of the hour prevented following the observation further.

Case 2.— A group of conjugated Actinophryes was noted, in which three lobes with rays proceeding from three centres indicated the union of three animalcules of considerably different size (fig. 4). Later in the evening another slowly approached and

FIG. 4. FIG. 5. FIG. 6.



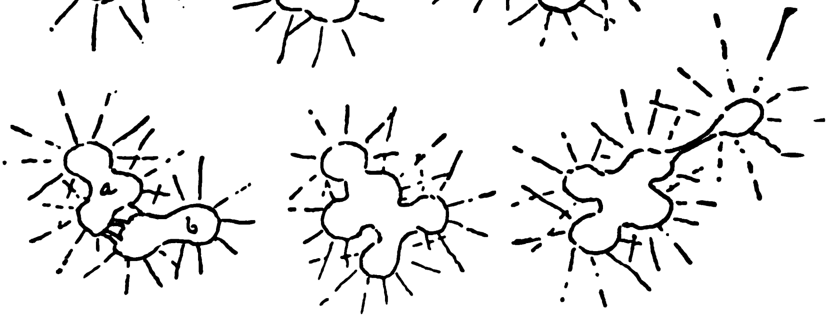


FIG. 7. FIG. 8. FIG. 9.

was gradually united to them. Half an hour later a fifth approached, and after a time became connected with the mass by two rather

ırge pseudopodia or filaments, and the process seemed to be arested there (fig. 5). Next morning the conjugation had gone o further with the new comer, but fission had begun in the origıal mass, as shown in fig. 6. At noon another large specimen ad approached the group, and by evening it had united with the ortion marked *a*, fig. 7, while the union between the subdivisions and *b* was then by two filaments, each group being pretty rell consolidated, though showing its lobes and rays centring in hem. In the evening of the second day the whole had become aore closely connected, as shown in fig. 8. Next morning (third lay) one of the group was stretching away from the rest, and coninued the fission until it was only connected by a long neck, as hown in fig. 9. The rays of the lobes seemed to be more vigrous than ever, reaching away four or five times the length of the liameter of the several lobes. The whole group had become opaine in color, the masses appearing to be divided into cells larger han before, with small, highly-refractive, colored bodies in these, noving with a swarming motion resembling the Brownian movenent.

The fission of the one lobe from the mass went slowly on to ompletion, but hardly was the connection between them broken, rhen both parts collapsed and fell to sudden ruin. The rays of he larger mass fell together into brushes at the two sides, and hose of the smaller did the same, these breaking up in granules nd dissolving like solid matter, and not being retracted or runing into the principal masses (fig. 10, *a*, *b*). The contents of

FIG. 10.

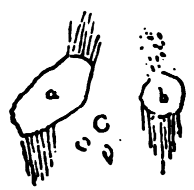


FIG. 11.

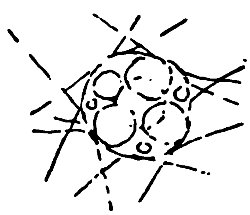
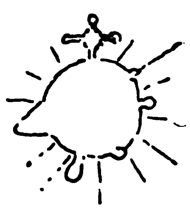


FIG. 12.



the masses floated away in irregular small portions of protoplasmic substance, each containing two or three of the minute opaque granules above mentioned. These passed out of the field while I was watching the final stages of the decay of the principal masses which soon showed nothing but a small patch of amorphous granular débris.

Moving the slide so as to follow the direction which the smaller bodies had taken, I soon came upon what seemed to be these, having the same general appearance as to size and color, and containing the small colored granules. As I had not been able to follow them continuously, for the reasons above stated, there is, of course, a possibility of mistake in recognizing them again. But I had had the slide under examination for several days, and, with the familiarity with its contents thus attained, felt no doubt myself as to the identity of the bodies. Some of these were nearly spherical, some pyriform; all seemed unicellular. After about half an hour, fine rays were visible about these bodies, and they assumed the form of a young *Actinophrys*. In this earlier stage there was much resemblance to a small *Amœba radiata*, but the development of the different specimens left no reasonable doubt that the *Actinophrys* has this appearance in its earlier stages of growth, and this is confirmed by subsequent observations to be noted.

A fact which appears to me important is this: that I was not able to trace fission in any specimen beginning with the single spherical individual. In all the dumb-bell forms, whether the neck were thicker or smaller, the lobes had each its own centre from which its rays projected, making two or more radial systems; and, though I watched with patience for an instance of such beginning of fission in a single specimen I have never found it. On the other hand, the cases of conjugation were extremely numerous, and were traced in very many instances through the whole process to ultimate fission again. In the cases in which this subsequent separation took place, the several individuals did not lose their identity in the union, but the case remained one of conjunction as distinguished from complete coalescence. The ray-systems of the individuals and the central circle of each remained throughout. All the cases of apparent fission which I observed were, therefore, precisely such as occurred when conjugation had taken place before: and though dumb-bell forms were constantly met with, which I had not traced through previous stages, they all, for aught that I had seen, might most naturally be regarded as cases of conjugation.

In some instances there was evidence tending to show that complete coalescing might follow conjugation, the body then going into the opaline state which I am about to describe, but I prefer to treat this as doubtful till confirmed by more thoroughly traced examples.

THE OPALINE CONDITION.

The *Actinophrys* was frequently met with in a condition which I have referred to as opaline, and it frequently was seen to pass into this condition after conjugation and subsequent separation. The whole body assumed a bluish, milky hue, and appeared divided into spherical cells of varying sizes, the number of these gradually diminishing and the size increasing. The rays became less numerous, smaller, and disappeared. In some cases before doing so they lost their radial direction and fell across each other like sponge-spiculæ (fig. 11). If we suppose a partly solidified endoskeleton to be absorbed before the solid parts of the rays, the successive phenomena would be intelligible, and this occurrence is part of the evidence bearing on that question of structure. The large opaline cells were much more transparent than the animalcule had appeared before, so that it was now practicable to focus up and down through the body, passing from the upper to the lower cells in turn. In the usual condition of the *Actinophrys*, everybody knows that this is impossible, though the animalcule is colorless. In these opaline cells are seen very small, highly-refractive granules, very nearly opaque but highly colored, red and green, which kept up the active movement before mentioned as resembling the Brownian movement. When the rays had disappeared, and sometimes before they were quite gone, the body seemed every way more plastic than in its usual condition, totally losing the firmness or rigidity which then marks it. Its surface sprouts into gemmæ more or less persistent, some of these taking the form of a central body with several radial arms, others being more like pseudopods of amœboid character, club-shaped and of varying rounded outline (fig. 12). In the cases I observed, although some of these seemed at times as if almost severed from the parent body, I did not see that separation occur, and the protruding parts were after a considerable time (from a quarter to half an hour) retracted again. I was disposed to attribute this to lack of aëration in the growing slide, as I saw, under similar circumstances, fission begun in *Trachelocerca*, and not carried to completion, the animalcule resuming its original form as if not having vigor for the attempted process.

In another case of an *Actinophrys*, which had been traced into the opaline condition, the plasticity went so far that a churning

movement was seen within it, almost as marked as the periodic movement seen within rotifers. In one instance the whole body had the appearance of a sac to which the churning motion gave change of shape, making it partly roll over on the bottom of the slide. In this case upon purposely agitating the water by pressing the cover-glass with a needle, the animalcule gradually resumed its regular rotundity, and after a time showed faint and thin rays again.

In some instances when the animalcule was watched through the changes leading into the rayless, opaline condition, it finally collapsed, its contents making only a mass of fine granular matter, in which I saw no subsequent motion or life, but only the ordinary appearance of decay and death. In others, however, the evidence of separation into a brood of young was as strong as in case 2, detailed above.

In several examples, soon after conjugation and subsequent separation had taken place, say within fifteen or twenty minutes, a single small rayed specimen, of the size and appearance of those already described, was found in close proximity to the mature individual under observation. It happened that these appeared on the under or upper side of the animalcule, so that the process of gemmation, if such it was, was not seen in the cases in which conjugation was watched. In one case, when a single *Actinophrys* was under the glass, no knowledge being had of its preceding history, there was the apparent excretion of a small mass which moved quickly out to the end of the rays and floated off. Its regular appearance attracted attention, and, keeping it under observation for half an hour, it had distinctly put forth rays and precisely resembled the young so often referred to.

This record of observations is offered as a contribution to the life-history of the *Actinophrys* without insisting too strenuously upon the conclusions to which they point. I have given the points in which the continuity of observation was broken, so that no more close connection of sequences in the phenomena may seem to be asserted than actually occurred, and that appearances needing verification may attract the attention of other observers. They point distinctly to two modes of reproduction; one, by single gemmation after conjugation, the other by segmentation of the parent into a brood of young after passing through the opaline condition described.

I purposely neglected examples which seemed to become encysted, as my method of manipulation did not afford the means of long-continued preservation of the specimens. The apparatus I found most convenient was a plain slide and cover-glass, which, when not under observation, was laid across the top of a small dish of water, a narrow shred from an old handkerchief connecting the edge of the cover-glass with the water below, and supplying the moisture by capillary attraction. The only limit to the preservation of the slide in the growing condition was the deposit of salts from the water by evaporation, which after a time became sufficient at the edge of the cover-glass to interfere with aëration. A single slide was, however, kept under observation for periods varying from a week to a fortnight.

Mounting Chick Embryos whole. By Charles Sedgwick Minot, of Roslindale, Mass.

[ABSTRACT.]

The author recommended the following method, for embryos under forty hours. The egg is opened in the usual manner in warm 0.5 per cent. salt solution, the blastoderm freed from the yolk membrane, then swayed with pincers to and fro in the liquid to remove the superfluous yolk, and then floated out on a glass slide, on which it is to remain permanently. It is next treated with several fluids; *all* of which should be dropped on the centre of the germ disk so as to spread out the blastoderm evenly by their centrifugal flow. Wash off thoroughly with distilled water. Remove the water as fully as possible by bibulous paper, and allow the specimen to remain fully spread out until the edges are dried. The embryo will then escape distortion during the further treatment. Care must be taken that the embryonic area remains moist. Drop on two drops of a ½ per cent. osmic acid solution, leave standing for two or three minutes until a slight browning is produced, wash off again with distilled water, stain with picrocarmine, which dyes the blas-

toderm after a variable time according to the intensity of the osmic acid action. The next step is important because it stops the further darkening by the osmium, which otherwise injures or ruins the specimen. Pour Müller's fluid, or 0.5 per cent. chromic acid solution on the slide and leave it over night. The next morning the blastoderm is ready for dehydration by alcohol, and mounting in the usual manner in balsam, or better in three parts pure Canada balsam mixed with one part dammar varnish, as furnished by the microscopical dealers.

Embryos mounted in this way make very perfect preparations surpassing, indeed, those otherwise treated.

ON A CONVENIENT METHOD OF EXPRESSING MICROMETRICALLY THE RELATION BETWEEN ENGLISH AND METRIC UNITS OF LENGTH ON THE SAME SCALE. By WM. A. ROGERS and GEO. F. BALLOU, of Cambridge, Mass.

IF we adopt the relation between the yard and the metre given by Kater we have:

$$.001^{\text{cm}} = .0003937079 \text{ inch.}$$

The aliquot part of the inch which is nearest this value is:

$$\frac{1}{2500}^{\text{inch}} = .0004000000 \text{ inch.}$$

The difference between these values is .000006291 inch. If therefore two scales are ruled side by side, one of which is 1000 to the centimetre and the other 2500 to the inch, we shall have a coincidence at the 63rd line of the inch scale, or more exactly at line 62.57 if there is an exact coincidence between the first lines of the two scales. If the assumed relation between the inch and the centimetre is maintained in the graduation, there will also be coincidences at lines 125.1 — 187.7 — 250.3 — 312.8, etc.

Since there is a coincidence for sixty-three spaces, each having

the constant value .0004 inch, an error of one line in the measured coincidence corresponds to an actual error of sixty-five ten millionths of an inch, counting from the first line.

The following is a description of the ruled bar to which the test here described has been applied.

This bar was ruled for the use of the American Watch Co., upon a machine built for me by Mr. Chas. V. Woerd, the mechanical superintendent of the watch factory. By his kindness I am permitted to exhibit it at this meeting.

On Tuesday, Aug. 9, commencing at 9h. 10m. A. M., Mr. Ballou subdivided four inches into forty equal parts. At 9h. 40m. A. M. the machine was started at 2500 spaces to the inch, and at 11h. 20m. P. M. the space of four inches had been subdivided into 10000 equal parts. The ruling carriage was then set back for coincidence with the first line and the machine was started at 1000 spaces to the centimetre. At 1h. 0m. P. M. of Aug. 10, the space of one decimetre had been subdivided into 10000 equal parts. The carriage was then set back for coincidence with the first line and the decimetre space was again subdivided into 100 equal parts.

It was hardly to be expected that in the continuous work of the machine for more than twenty-nine consecutive hours the theoretical values of the coincidences should be maintained under the wide variation of temperature which took place between the day and the night. Moreover the tremors occasioned by the heavy machinery of the factory, and especially the blows of a power hammer which is not very far distant, were sufficient to account for a portion of the errors introduced. Nevertheless the matching of the (triple) lines representing $\frac{1}{10}$ of an inch with the corresponding lines of the band is nearly perfect. In the metric band there is at one point a deviation amounting to about one-half of the width of the lines, but the coincidence is soon recovered.

In counting the coincidences between the two bands, of which there are 158, the following method was pursued. After Mr. Ballou had completed the graduation, he arranged a simple carriage for facilitating the count. He carefully counted the coincidences and communicated the results to me. I then compared them with the computed numbers.

It is to be noted especially that Mr. Ballou had no means of knowing whether his count would agree with the actual number of

lines forming a coincidence. The deviations from the computed values are given in the following table, for each of the 158 coincidences.

+0	+2	+5	−1	−1	+0	−2	−2
+0	+4	+5	−2	−3	+0	−2	−2
+0	+4	+5	−5	−1	+0	−2	−2
−1	+4	+6	−5	−2	−1	−4	−1
−1	+4	+5	−5	−2	−1	−2	−2
+0	+5	+4	−5	−3	+1	−2	−1
+0	+4	+4	−6	−1	−1	−2	−1
−1	+4	+3	−1	−1	−2	−1	+0
+0	+4	+3	−1	+0	−2	−3	+0
+2	+5	+3	+1	−3	−1	−2	+1
+2	+5	+3	−2	−2	−1	−2	+1
+2	+5	+0	+0	−1	−2	−2	+1
+3	+4	+2	−1	+1	−2	−1	+1
+3	+5	+2	−3	−2	−2	−1	+1
+3	+6	+2	−3	−2	−3	−1	+1
+3	+5	−3	−4	+0	−3	+0	+0
+4	+4	−3	−2	−3	−1	−2	−2
+1	+4	−1	−3	+1	−2	+0	−2
+2	+5	−1	−3	+0	−3	−2	....
+1	+5	−2	−4	−1	−3	−3	....

It will be seen that the greatest cumulative error is near line 2000, the maximum value of the *difference* between the two values of the two units at this point amounting to about one thirty-thousandth of an inch. It is to be noted that the apparent periodicity of the numbers representing the coincidences does not necessarily indicate a periodicity in the screw. In fact, this method of comparison gives us no information on this point, since the coinciding lines in the two systems were ruled at the same part of the screw. Finally, the four inches of this bar are nearly standard at 62°, and the decimetre is nearly standard at the same temperature.

FREEZING MICROTOME. By THOMAS TAYLOR, of Washington, D.C.

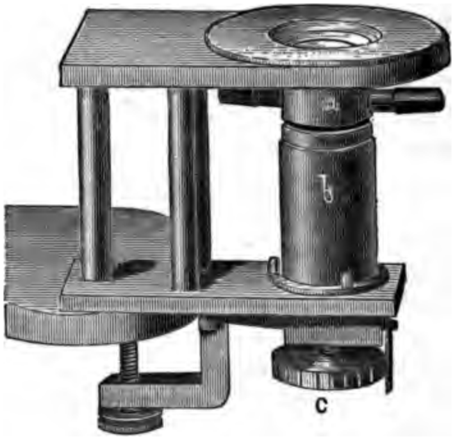
ALL microscopists who take an interest in the study of histology and pathology have long felt the necessity for a better method of freezing animal and vegetable tissue than has heretofore been at their command. The methods of hardening tissue by chemical agents need not be described at this time, as they are well understood, and moreover are successful as far as they go. The principal objections to the whole system are that the tissues are more or less distorted by the chemical solutions used to harden them; the chemicals are expensive, and the tissue requires to be exposed to their action for a considerable time, in some cases for a period of months. To avoid these objections the freezing microtome is introduced. Ether and rhigolene have been employed with some degree of success, but great disadvantage attends the use of vapor, or spray of these liquids. Both are expensive and generally very unsatisfactory in action; they cannot be used in the presence of artificial light because of danger of explosion. Two persons are required to attend to the manipulations, one to force the vapor into the freezing box, while the other uses the knife. The moment the pumping of the ether or rhigolene ceases, the tissue operated on ceases to be frozen, so ephemeral is the degree of cold obtained by these means. The "Rutherford" machine is also defective. In using it, I with others have found it necessary to immerse the whole machine in a freezing mixture in order to get a sufficiently low temperature to bear on the tissues. The microtome which I have constructed presents all the advantages of any plan hitherto employed in hardening animal or vegetable tissues for section cutting, while it has many advantages over all other devices employed for the same purpose. The method of freezing the tissues which I propose may, when compared with any other mode heretofore introduced, be said to be instantaneous. So quickly is the gum-water frozen, which is used to secure the adherence of the tissue on the freezing chamber, that it is found necessary to place the gum and tissue in position before the freezing process is commenced, otherwise the gum would be so firmly frozen that the tissue would remain loose on the frozen gum surface.

The general appearance of my freezing apparatus resembles that of an ether microtome; but in their working parts and results, the two instruments differ materially. The method of using my microtome can be best explained in connection with the illustration.

Fig. 1 represents the microtome when secured to a table. *a* is the freezing chamber; it resembles a pill box, constructed of metal and may be of any dimension required, provided it is in harmony with the framework which holds it in position.

A brass tube enters it on the right side as shown. On the left side is a second tube similar to the other. The first tube is used to fill the box *a* with a freezing liquid, salt and water, of the tem-

FIG. I.



perature of zero. The object of the second is to remove the air from the box as the liquid flows into it, and also to furnish an exit for the latter. This tube is bent at right angles, its inner portion ascending vertically to within an eighth of an inch of the top of the chamber (*a*), thus bringing the freezing mixture directly in contact with the top of the box. In order to secure a constant current of freezing liquid, I place above the microtome on a bracket a pail filled with finely chipped ice, combined with an equal quantity of common salt. The ice and salt quickly melts, the liquid thus formed consisting of salt and water is made to flow through a rubber pipe attached to the lower part of the pail, while the other end of the same pipe communicates with the right hand tube of the chamber at *a*. A rubber pipe is likewise secured to the second brass tube described. The water should not be allowed to waste. I secure it in a second pail to be returned to the first pail for continued use. In this way great economy is secured in the freezing material. I find it necessary as a matter of further economy, to limit the rate of exit of the salt and water. I therefore

make the supply pipe somewhat larger than the exit pipe, and to economize still further, I secure within the lower end of the exit pipe a glass tube the outer diameter of which is about the thirty-second part of an inch. Sometimes in practice it is found that a small particle of vegetable matter will close up the orifice of the glass tube and prevent the constant flow of water. By means of a pin this may be removed and the flow at once established. Should a stoppage of flow arise from any other cause, the glass tube may be removed from the rubber pipe and blown through from its smaller end, which will remove all obstructions. With a little practice the freezing process may be constantly kept up as long as desired, by simply renewing the chipped ice and salt in the upper pail.

FIG. 2.

In all my experiments I prefer a long knife such as is generally supplied for section cutting. Should the cold within the chamber (*a*) be too intense, the edge of the knife is liable to be turned and the cutting will be imperfect. When this occurs I stop the flow of water through the chamber by placing a spring clothes-pin as a clip on the upper tube. By the use of the freezing microtome, the softest tissue may be hardened and cut in sections, and mounted within a few moments, all chemical hardening processes being rendered wholly unnecessary. *a*, fig. 2, represents a sectional view of freezing chamber, as seen apart from its framework. *b* contains a solid cylinder of box wood to which the frozen chamber is secured. The arrow represents the inward and outward flow of water. At the bottom of the figure is the index screw by which the thickness of the section is regulated.

TITLES OF OTHER PAPERS READ BEFORE THE SUB-SECTION OF MICROSCOPY.

BACTERIA AND MICROCOCCI, AND THEIR RELATIONS TO PLANT CULTURE.[1] By Thomas Taylor, of Washington, D. C.

A NEW AND IMPROVED FREEZING APPARATUS FOR USE IN SURGICAL AND DENTAL PRACTICE, BEING A SUBSTITUTE FOR ETHER SPRAY. By Thomas Taylor, of Washington, D. C.

ON A CONVENIENT FORM OF SLIDE CASE. By Robert Brown, jr., of Cincinnati, Ohio.

[1] Printed in Science, Sept. 17, 1881, and in Cincinnati Medical Review for Oct., 1881.

SECTION B.

NATURAL HISTORY.

PAPERS READ.

On the Cause of the Arid Climate of the Western Portion of the United States. By C. E. Dutton, of Washington, D. C.

Many questions arising in the study of western geology involve the consideration of the arid climate of the region and I have frequently been led to inquire as to its cause. Arid climates are usually attributed to the passage of prevailing winds over high mountain chains. As they ascend the mountains upon the windward sides they are cooled by the expansion due to diminished barometric pressure, their capacity for moisture is reduced and an abundant precipitation takes place. Descending upon the leeward sides these changes are reversed; the air is heated, its capacity for moisture is increased, it becomes dry, and having been depleted of moisture is supposed to be incapable of yielding a copious supply to regions beyond. This explanation is no doubt good for some localities. Peru is a case in point and for that country it seems quite perfect. It is believed by many that it also explains the arid climate of the western half of the United States, and that the Sierra Nevada is the range which robs the winds of that region of the moisture which otherwise would make its vast expanse fertile. Reflection upon this case has led me to a different conclusion.

It is unquestionable that the Sierra Nevada abstracts a notable amount of moisture from the winds blowing from the Pacific. Mr. B. B. Redding, the Land Agent of the Central Pacific Railroad, has kept for several years excellent records of the rainfall at many stations in California and Nevada, and informs me that along the main road from Sacramento to the summit pass of the Sierra, the annual rainfall increases at the rate of one inch for every one hundred feet of altitude At the summit the mean annual precipitation exceeds ninety inches. It is not improbable that this large amount is considerably exceeded at numerous points along the crest of the range. It seems clear therefore that the winds which

blow over the Sierra are to some notable extent depleted of moisture and the effect must be to at least aggravate the aridity of the regions lying immediately east of the range. But I think it can be made evident that this effect is relatively not great, and that the elevated region of the west would be on the whole very nearly as arid as now if the Sierra Nevada were obliterated as a mountain range. Nor can the other and lower ranges lying east of the Sierra affect the case materially, for surely more than ninety per cent. of the rain and snow which fall upon them are reëvaporated *in loco* and the atmosphere ultimately suffers no material loss of moisture.

When the winds blow constantly from a cool to a warmer region they become warm and therefore dry; and if they have no opportunity to take up more moisture on the way the passage from a cool to a warm region is a sufficient cause of aridity. This is, I conceive, the state of affairs which determines the climate of the western mountain region. The winds blow constantly from the western quarters, being the "return trades." Local winds and perhaps large cyclones occasionally turn the weathercock toward an easterly quarter, but the general drift of the great atmospheric ocean is ever from west to east.[1] This prevailing air drift comes from the Pacific and reaches the coast nearly or quite saturated with moisture. The quantity of moisture required for saturation is dependent chiefly upon temperature; and the temperature of the air as it reaches the coast is determined by oceanic conditions.

From the Aleutian Islands, a coastwise ocean-current moves southward, having a breadth of 500 miles or more, and extending as far southward as the latitude of Cape St. Lucas. Off British Columbia and Alaska it may be regarded as a warm current relatively to the adjoining land. Off the Californias although its temperature rises notably with its southward movement it may be regarded as a relatively cool current. On the more northerly shores its effect is to make the climate of the adjacent coast warmer than it would otherwise be; and its effect on the more southerly shores is to make them cooler. Stated in another manner, the relation is such that the temperatures of the land areas in the high latitudes are lower than those of the ocean, while in the low latitudes they are higher. In the high latitudes, therefore, the winds blowing from the Pacific are cooled by the land; in the low latitudes

[1] This general statement requires some qualification when applied to southern Arizona and southern New Mexico, though it is in the main applicable even there.

they are warmed by it. Hence the precipitation is copious in the former regions and meagre in the latter. Between the two belts where these opposite effects are pronounced is a region where they shade into each other, and though this intermediate region cannot be marked out by distinct boundaries it may still be said to exist in latitudes lying within the valley of the Columbia river.

The cause of an arid climate thus indicated may be regarded as generally operative throughout the western mountain region; and it will no doubt appear upon full consideration to be much more potent and widely extended in its action than any or even all of the mountain ranges could be. It is, however, greatly modified by the intervention of local causes, which occasionally mask or obscure it. The precipitation in different portions of the region is highly irregular and several modifying causes can be indicated which, though they do not nullify the more general one here set forth, frequently become much more conspicuous in their effects. For instance, it is well known that the heaviest rainfall in the United States, excepting possibly upon some mountain tops, occurs upon the coast of Oregon and Washington Territory. But as already indicated this is the locality where we find the neutral axis, so to speak, of the alleged causes favoring respectively humidity and aridity, and where their effects are at minimum or even at zero. Moreover, the westerly winds saturated with moisture here strike the coastwise mountains, and are suddenly thrown upward several thousand feet before they have had time to feel the heating effect of the land which is here very slight; and the precipitation is thus very copious. Descending to lower levels inland they soon become dry and produce a sub-arid climate.

The most frequent variants of climate are the great differences of altitude in different portions of the west. The mountain tops and summits of the plateaus are always well watered, and in any given latitude the rainfall increases or diminishes at a fairly definite rate with the altitude. But the variation of rainfall with altitude is by no means a simple ratio. Between 4500 and 6000 feet the difference in rainfall is not great, between 6000 and 7500 feet it is very considerable; between 7500 and 9000 it is still greater.

Moreover the rainfall is greater *ceteris paribus* in high latitudes than in low latitudes. In passing from the southern to the northern boundary, if we compare localities of equal altitudes

along any given meridian, we shall find the rainfall steadily though perhaps not uniformly increasing. This is an obvious consequence of the theory suggested.

Although no very great effects upon the general condition of aridity are here attributed to the depletion of moisture by the passage of the winds over mountain ranges, it is still true, no doubt, that highly important local effects are thereby produced. The rainfall at the eastern base of the Sierra Nevada, and for two hundred miles east of it, is most probably reduced very greatly by this cause. In the sink of the Humboldt river, the annual precipitation seldom reaches four inches, and may average not more than three inches; but, as we pass eastward beyond the *wake* of this range, its effects become gradually less, and long before the Wasatch is reached they have become inconsiderable. Since the Sierra Nevada is the longest, highest and widest of the individualized ranges of the Rocky system, its local effect upon the humidity of the plains and valleys lying immediately under its lee is greater than that of any other. But the same kind of effect is perceptible in some other ranges.

The discussion of the causes of local variations in climate might be almost indefinitely extended. Nothing more is designed here than to advert to one general cause of aridity which prevails over the entire region, and which everywhere persists, though it is often obscured, sometimes reversed and sometimes reinforced by local causes.

THE EXCAVATION OF THE GRAND CANON OF THE COLORADO RIVER. By C. E. DUTTON,[1] of Washington, D. C.

[ABSTRACT.[2]]

THE lecturer first exhibited lantern views of the chasm, taken from a locality near the middle of its length, which show the simplest and most typical form of the cañon. It consists of an upper chasm 2,000 feet deep, and five to seven miles wide, including a broad

[1] Captain U. S. Ordnance Corps, U. S. Geological Survey.
[2] This paper was given as a lecture on Wednesday evening.

l comparatively smooth floor between the palisades. Within s floor is sunk an inner and narrower gorge, 3,000 feet deeper l about 3,200 to 3,600 feet wide. The rigorous uniformity in : profiles of the palisades and their ornate architectural appear-ɔe were adverted to. The strata through which the chasm is cut › of Carboniferous age, excepting the lowest 400 or 500 feet, ich are Lower Silurian or Primordial.

The audience was then conducted north of the river to the great sert-plain of the neighboring region, where the general char-ter of the topographical features was exhibited by appropriate :tures. About forty miles north of the cañon begins a series terraces, ascending step by step to the northward, called the :rraces of the High Plateaus. Each terrace consists of a dis-ict geological formation beginning below with the Permian; d, rising by successive steps upon the Trias, the Jura, the Cre-ceous and the lower Eocene, we at last reach the top of the ɔst recent formation (lower Eocene) of the region. Each ter-ce terminates in a gigantic cliff-wall of remarkable architectural pearance, as shown in the illustrations.

Reaching the summit of the Eocene, and looking backwards d downwards over the stairway of terraces, the facts thus briefly inced at were discussed from a geological standpoint. The for-ıtions consisting of Permian, Mesozoic and Eocene strata, dis-ɪsed and abruptly cut off in the terraces, are inferred to have ıched formerly much farther southward, and in fact to have ex-ıded over the entire Carboniferous platform (13,000 to 15,000 ıare miles) now drained by the Grand Cañon. The total thick-ss of the beds thus denuded was on an average very nearly ,000 feet.

It was then shown that this denudation began about Middle ɪcene time and has continued until the present. By far the eater part of it was effected during Eocene and Miocene time. The great amount of uplifting undergone by the Grand ıñon platform was then shown, being in the aggregate (during :rtiary and Quaternary time) 16,000 to 19,000 feet. This ɪount, though great, is surpassed by other localities of the :st. The present altitude is the difference between the total up-ting and the thickness of strata denuded, and it varies from 700 to 9,200 feet. The elevation was not at a uniform rate,

but was broken by periods of repose, the evidences being recorded in the drainage channels and faults.

The excavation of the present Grand Cañon began after the greater part of the denudation had been accomplished. The river began to flow in Eocene time, and had to cut through 10,000 feet or more of later formations before it entered the summit beds of the Carboniferous which now form the highest crest of the cañon wall. The beginning of the present Grand Cañon was in Pliocene time. The evidence of this is cumulative. Collectively it is overwhelming, but as it consists of many discrete parts, no one of which by itself alone would be conclusive, it will not be advisable to attempt to present the evidence for want of time.

The mechanical process of excavating the cañon was then alluded to. It is customary to say that the river cut it. This is so far true, but it is less than half the truth. The processes may be referred to two groups, corrasion and weathering, both of which are highly complex. Corrasion is the action of a river upon its bed by which, under certain conditions (the general nature of which was briefly explained), it scours down its channel in the rocks to lower and lower depths. But the cut sawed by the river cannot be wider than the water surface of the stream, and the Grand Cañon is five to eleven miles wide. The cañon is widened by the weathernig of its walls. This is an extremely complex process, though now it has come to be pretty well understood, and under the conditions prevailing in the Plateau country, it gives rise to many curious, beautiful and instructive results. A single instance was given by way of example, viz.: the operations by which the remarkable cliff-profiles of the cañon are established and maintained. The discussion of the details of natural architecture would require a large volume.

The hearers were then conducted to the grandest portion of the chasm, the Kaibab Plateau, and a description of its superlative scenery was given, illustrated with lantern pictures.

A Short Study of the Features of the Region of the Lower Great Lakes during the Great River Age; or Notes on the Origin of the Great Lakes of North America. By J. W. Spencer, of Windsor, N. S.

I purpose bringing before this section a few notes on the physical features of the Great Lake Region, which have a bearing on the origin of the lakes themselves, with a few deductions therefrom. Although the bibliography of the subject is scanty, I will not detain the Association with a notice of what has been written.

While working out the origin of the Dundas valley, at the extreme western end of Lake Ontario, the discovery, that the present great rock-bound valley is only one of insignificance compared with the buried channel of Preglacial date, led to the broader study of the origin of the lake-basins themselves, as the buried channel in the Dundas valley appeared to form a portion of the Preglacial outlet of the basin of Lake Erie into that of Lake Ontario. On this subject my first paper was read last March before the American Philosophical Society, and was published in the last volume issued by it. The same paper has been subsequently reprinted in volume Q_4 of the Reports of the Geological Survey of Pennsylvania.[1] To this paper frequent reference will be made. During the present summer further details have been worked out, and observations have also been extended to the more important small lakes of Central New York. But only some of the results of these observations can here be noticed.

Theories of the origin of the Lakes.—Of these there are three:—1, the basins of the lakes are geological valleys; 2, the basins were excavated wholly or partly by glacier-action; 3, the basins were excavated by atmospheric and fluviatile erosion, with their outlets closed by the drift of the Ice Age, assisted probably by geological uplifts. The relative value of these explanations will be seen in the succeeding pages.

Features along the Preglacial Outlet of the Erie Basin into the Basin of Lake Ontario.—The Niagara escarpment encloses the

[1] The title of the above mentioned paper, read March 18, 1881, is—"*Discovery of the Preglacial Outlet of the Basin of Lake Erie into that of Lake Ontario; with Notes on the Origin of our Lower Great Lakes. By Prof. J. W. Spencer, B. A. Sc., Ph. D., F. G. S. King's College, Windsor, N. S.*

western end of Lake Ontario by its hills, which face the lake just beyond its southern and western shores. Through this escarpment, at the extreme end of the lake, the Dundas valley is excavated. In the expanded valley the western portion of Burlington Bay and the city of Hamilton are situated. Westward however of the latter place, the excavation through the escarpment closes to a width of rather more than two miles. Of these hills, the lower 250 feet are composed of Medina shales, and over these there are the thin intercalated beds of Clinton dolomites and shales, surmounted by a still greater development of compact Niagara dolomites. The general altitude of the rocky boundaries of the valley is rather more than 500 feet above Lake Ontario (516 feet north of Dundas, and 510 feet south of Ancaster). After the escarpment closes to form a valley of about two miles in width, just beyond the limits of the city of Hamilton, it extends westward for six miles, but at Copetown it becomes covered with drift, while on the southern side, at Ancaster, less than four miles distant, it abruptly ends. Westward of Copetown on the northern side of the valley, the escarpment continues, but it is more or less covered with drift, through which there are occasional exposures of a rocky floor. On the southern side of the valley, as just stated, the escarpment ends, and the country beyond consists of a large basin filled to a great depth with drift deposits traversed by deep valleys.

The deeper portion of the valley, in which Dundas is situated, is separated from the lake by Burlington Heights, a ridge of stratified gravel that rises 108 feet above the lake, being an old beach composed of Hudson River pebbles. Behind this ridge is the extensive Dundas Marsh, and farther up the valley is the town itself.

As we ascend the Dundas valley we find that the channel between the rocky walls of the Niagara limestone becomes filled with drift which rises in places to the summit of the escarpment itself, but which is traversed by deep ravines.

At the upper end of the Dundas valley proper the character of the country differs from that in the valley. There is a large basin which may be defined approximately by drawing a line from Ancaster village to the Grand River on the east, thence along the hills southward of the Grand River to near Brantford, thence northward to the main line of the Great Western Railway, and

thence eastward from near Harrisburg to Copetown and the north side of the Dundas valley. Much of this basin is from 50 to 100 feet lower than the country outside of it, which is underlaid by an almost horizontal limestone floor, 500 feet or more above Lake Ontario, and covered with only a moderate thickness of drift. But in this basin the drift is developed to an enormous extent, seen not only in the ravines in the eastern portion, which pass to the Dundas valley, but also in very deep wells. Even the drift divide, between the ravines (almost dry) opening to the Dundas valley and to the Grand River, is much lower than the level country outside of this drift-filled basin.

The *drift* in the basin extends to a considerable depth. The highest elevation between the two systems of drainage is about 440 feet above Lake Ontario, or 113 feet above Lake Erie, while the ravines and deep wells, which seldom reach the rock, indicate an absence of hard rock in many places, at least, to a level below the surface of the latter lake. In the Dundas valley proper, the depth of drift is very great, and cannot be much less than 1000 feet half of which is below the level of Lake Ontario; for near the margin of the narrower portion of the valley produced to Hamilton, the drift was found in a well to reach a depth of 227 feet below the lake, in a bed of Medina Shales, and in the centre of the valley (two miles wide) to a calculated depth (in rocks of the Hudson river period) of not less than 400 feet (which would be deep enough to drain Lake Huron), and would accord with the soundings in the western end of the somewhat alluvial filled lake. This being the case the depth of drift in channels in the basin west of Ancaster, not more than seven miles distant, in all probability reaches a similar depth.

Into the western portion of this basin, I have found that at least two Preglacial rivers emptied, namely: the Upper Grand river, then entering the basin near Harrisburg; and Nith's river, emptying northwest of Brantford. From the southeastern corner of the basin the broad depression of the Grand River valley extends to Lake Erie.

The Grand River Valley is characterized by a broad depression two miles or more in width, which has a lateral elevation of about 440 feet above Lake Ontario or 113 feet above Lake Erie, and still farther by boundaries more than 160 feet above the latter lake.

The drift-filled bed of the river at Brantford is only 66 feet above Lake Erie; at Seneca, 37 feet; and at Cayuga (more than 15 miles from the mouth), it is down to the lake-level itself. The lower portion of the river is through a broad marshy country. At Dunville, a few miles from the lake, piles had to be driven to a great depth to get a foundation for an embankment across the river. The margins of the valley are underlaid by limestones (Onondaga on one side, and Corniferous on the other) though the river valley is excavated out of the softer rocks of the Onondaga group.

In its meanderings, the river along portions of its course in several places crosses small spurs of Onondaga shaly limestones, but their character in no place precludes the possibility of an adjacent buried channel. At most, all the waters that could come down the Grand River, even with an increased pitch of the country, and a larger precipitation of moisture, would scarcely be able to more than excavate the present bed. The country, on either one side of the river or the other, is remarkably broken within the limits of the valley, but beyond, it is equally remarkable for its level surface. The detailed features, I cannot here enter into, but suffice it to say that my former conclusions, that the preglacial outlet of the basin of Lake Erie into that of Lake Ontario was along the buried portions of the Grand River and Dundas valleys, are sustained. This view is greatly strengthened when we study the hydrography of Lakes Ontario and Erie, and the ancient buried valleys connected with the latter lake.

That the Dundas Valley is not of glacier-origin is almost too apparent for consideration. Not only have we found a river capable of excavating it, but the very nature of the valley, with more or less perpendicular walls, is not of such a character as to admit of its excavation by the erosion of glaciers. The direction of the axis of the valley is about N. 70° E. The summit edges of the walls on both sides are sharply angular and not rounded; nor is this angularity due to frost action to any extent, as shown by the character of the talus. The surfaces of the rocky floor of the adjacent country are often covered with ice-markings, but the *striæ* are not parallel with the axis of the valley. There are also several preglacial tributary *canyons* or valleys, but all these have different directions to the glaciated surfaces. Again, no glaciers

in this region could have moved northeastward, and equally impossible would it be for any eroding streams from melting glaciers to move southwestward up an inclination of several hundred feet. These remarks have an important bearing on the origin of Lake Ontario itself; for any force, that could have excavated this valley in hard limestone, along the true axis of the lake to a depth of nearly a thousand feet, would be no unimportant agent in the excavation of the lake itself, lying mostly in Medina and older shaly rocks.

Basin of Lake Ontario.— Lake Ontario itself lies only in the lowest portion of a much larger basin; reaching, on its southern and western margins, to the base of the Helderberg and Niagara escarpments; on the northern, to the gently rising Lower Silurian and crystalline rocks; and on the eastern, to the foot of the Adirondacks. The greater portion of this lake-basin is excavated out of shales of the Medina, Hudson river, and Utica epochs; and in the northeastern shallow portion, out of the more calcareous rocks of the Trenton group.

In my former study of this lake, I have shown from the soundings that a narrow buried channel, of 90 fathoms depth or more, extends for about ninety miles from near Oswego to the 78th meridian and at a somewhat less depth (70 fathoms) to near the meridian of the Niagara river. Westward of this limit, the lake is more uniform in depth, being silted up. The deepest sounding nearly north of Pultneyville is 123 fathoms or 738 feet. This deep channel nowhere approaches to within twenty miles of the Canadian shore, although it is within six miles of the shores of New York. From the Canadian shore, the lake-bottom slopes gently at an average depth of about 25 feet in a mile to the deep channel, but from the New York side, the slope for three or four miles is double that on the northern side, and then comes a plunge over the face of an escarpment which in less than two miles is 336 feet, comparable with the Niagara escarpment westward, for some distance, of the Niagara river. In one mile across the escarpment, the descent is 210 feet. The summit rocks of this submerged escarpment are of Hudson river age, capped by a thin stratum of gently sloping Medina-shales. The escarpment can be traced for nearly 100 miles, but in proceeding westward, the lower portion becomes buried in the sediments carried down and deposited in the lake.

Westward of the Niagara river, the escarpment is obscured by sediments, yet its existence is made known at the exit of the Dundas valley and elsewhere.

It can now be seen that a great river extended from Lake Erie through the Dundas valley, and through Lake Ontario, at the foot of a now submerged escarpment, receiving along the way the waters from great buried river channels, of which the Genesee river was one of the largest, as the Niagara was not yet in existence.

Before considering further the causes of the excavation of the lake, let us examine where there could have been an outlet for the waters of this great river system.

Possibilities of an outlet by the St. Lawrence.—The northeastern portion of Lake Ontario is very shallow. Although the country surrounding it is low, yet it is underlaid by hard rocks which are so frequently exposed, through the moderate thickness of drift, as to preclude the idea of a great buried channel existing adjacent to the St. Lawrence, which a short distance below the outlet of the lake flows over Laurentian rocks. However, in northern New York, but southward of the St. Lawrence, there are some unimportant buried channels connected with the Ontario basin. The St. Lawrence river itself is modern from Lake Ontario to the junction of the Ottawa river, though the lowest portion of the river is conspicuously of ancient date, with pot-holes indicating a depth of nearly 1200 feet. Without a considerable change of level, such as either that which would be produced by a local subsidence of northeastern Ontario and the upper St. Lawrence, or a very great northern subsidence during a period of southern elevation, any possibilities of the preglacial outlet of the Ontario basin by the St. Lawrence seems impossible.

Possibilities of an outlet at the southeastern end of the lake.—Between the eastern shores of Lake Ontario and the foot of the Adirondacks, the broad plane appears to mark the former lake-bottom before the lake contracted to within the present limits.

This remark holds good for the "Great Level" between the southern margin of the lake, and the escarpment to the south, although 150 feet above it. The level country southeast of the lake is underlaid by almost horizontal Palæozoic rocks, which are exposed along many of the streams, and are covered generally

with no great thickness of drift. These rock exposures occur as far south as a short distance north of Oneida Lake. They are also seen along the Oswego river, and the lower portion of the Seneca. However, there is a deeply buried basin in the region of Onondaga lake. Oneida lake is only 60 feet deep, and 127 feet above Lake Ontario, and it is situated in a basin of drift.

Onondaga lake is 119 feet above Lake Ontario, and is about 65 feet in the deepest sounding. It is a modern lake situated in a great drift-filled basin. The shallower portion of this basin is toward the northern end of this lake; it increases in depth on approaching Syracuse, but again becomes somewhat shallower on passing southward of this city. The drift-filled basin reaches to a depth of about 290 feet below the surface of Lake Ontario. Southward of Syracuse the country rises to the escarpment forming the southern boundary of the Ontario valley.

For many years, suggestions have been made that the Preglacial outlet of Lake Ontario was by the buried basin just described, emptying its waters by the Mohawk and Hudson rivers into the Atlantic. However, this outlet is not possible as shown by Mr. Carll, for the Mohawk river passes over metamorphic rocks at Little Falls, Herkimer County, at an elevation above Lake Ontario of about 125 feet, without the possibility of an adjacent buried channel through the range of hills, through which the Mohawk valley is cut. The origin of the Onondaga basin, then, appears to have been by a river valley extending from the Adirondack mountains westward, and opening into the Ontario basin northward of the Cayuga lake, having formed along the course the basin, now occupied by drift material and Onondaga lake, and perhaps that also of Oneida lake.

Most of the other lakes, especially those having a more or less meridional direction, lie in great valleys, and are only closed up ancient river valleys. All of these lakes, except two, Seneca and Cayuga, are at a considerable elevation. One of the deepest of these elevated lakes is Skeneateles (613 feet above Lake Ontario, and 320 feet deep). This lake, as well as Owasco, has a northern modern curved outlet over rocky barriers. They lie in valleys several hundred feet deep (300 feet or more) and evidently emptied into the Susquehanna river in some former geological times. The valleys of these lakes as well as several river valleys in the region now having northern outlets (such as those of Onondaga, and But-

ternut Creeks) all radiate from adjacent or common points as they extend northward, evidently showing a former southern discharge. However, it is exceedingly difficult to determine how much of the valleys are of preglacial, and how much of interglacial or postglacial date, for there are evidently three periods of erosion, — the valleys produced in the interglacial and modern epochs coinciding.

Thus far no apparent outlet of the great ancient Ontario basin has presented itself. However, one other route at first appeared possible, — *by the Seneca Lake, Chemung and Susquehanna Rivers.* The features favoring this suggestion are: the greatest depth of Lake Ontario north of Seneca Lake; the depth of Seneca Lake, which is 612 feet, 423 feet below the level of Lake Ontario; the direct continuity of Seneca Lake Valley with that of the Chemung, at Elmira, and of the latter valley with that of the Susquehanna at Sayre. The valley of Chemung above Elmira is much smaller than the portion below which joins it at a considerable angle, but this portion of the river just above Elmira is more modern than the Preglacial course of the Chemung, which from Corning passed directly to Seneca valley at Horse Heads. One thing is certain, the Ontario basin as it was emerging from the last subsidence of the Glacial period, flowed by the route indicated and lingered sufficiently long at the level of the upper part of Seneca valley, to produce beaches at the same level along various portions of the margin of the basin.

Unless there was a great relative change of continental level, the route just described could not have been the Preglacial outlet of the basin of Lake Ontario, as a considerable portion of the *canyon* of the Susquehanna for several miles below Towanda (738 feet above the sea) "has a rocky bottom" (Lesley).

Cayuga valley would not afford any better outlet, as its summit is 200 feet higher than that of the valley of Seneca Lake, and connects with the Susquehanna by diminished valleys.

A pot-hole at the mouth of Chesapeake Bay indicates an ancient depth of the Susquehanna River to at least 1170 feet below sea level.

Many of the streams in northern Pennsylvania, now tributaries of the Susquehanna, indicate an original northward flow to Seneca Lake.

For the Preglacial outlet of the Ontario basin to have been by

he Seneca and Susquehanna valleys, a very great local oscillation ould have been necessary, but of this we have no evidence.

Basin of Lake Erie.—The exceedingly shallow basin of Lake rie has its bottom as near a level plane as any terrestial tract can e. The mean depth for a great portion of the basin does not vary eyond the limits of from 12 to 14 fathoms. A deeper portion f the lake, however, is found southward and eastward of Long oint, where for about 40 miles the depth exceeds 20 fathoms, n some places reaching 35 fathoms. This deeper portion turns round Long Point, and takes a course towards Haldemand county, n Canada, in the direction of the present mouth of the Grand iver. The outlet of the lakes towards the Niagara river has a ocky bottom (corniferous limestone).

Basins of the other Great Lakes.—As I have pointed out elsehere, Lakes Huron and Michigan partake of the character of subërial valleys traversed by river systems.

Dr. Newberry considers that these two lakes have been separated t a comparatively recent period. With this view I am inclined concur, and consequently have classified Huron with the Lower reat Lakes.

On a careful study, Lake Superior appears to be a valley of eroion, rather than a geological valley, although its position may have een partly decided by geological depressions.

Lake Michigan is even now almost deep enough to drain the reater lake, whose probable outlet was along a route between the outh of the Chocolate river, and the northern end of Lake Michian, across the country adjacent to Manistique lake and river.

It has been frequently suggested that Lake Michigan had a Prelacial outlet into the Illinois river. Since a small rock-cutting as made near Chicago, some years since, waters from the lake ow pass to the Mississippi drainage. However, the Preglacial utlet has not yet been discovered, although it is highly probable hat such a buried channel exists.

The Preglacial Outlet of Lake Huron.—As the depression from Georgian Bay to Lake Ontario is underlaid by a rocky floor, more than 200 feet above the former water, there remains only two possible routes for the Preglacial discharge. One of these routes is that by the straits of Mackinac, where the deepest sounding is nly 252 feet, with the northeastern portion of Lake Michigan

very shallow. The other and probable route is by a buried channel to Lake Erie. The southwestern counties of Ontario are generally low and covered with 50 or 75 feet of drift, with occasional channels more deeply buried. The deepest of these channels is between Vienna and Port Stanley, in the Province of Ontario, where borings have been made to a depth, through the drift, of 200 and 152 feet respectively, beneath the surface of Lake Erie. These borings appear to indicate marginal depth of a great channel excavated out of an area of soft Devonian shales. Dr. Hunt has collected many of the records of the borings in this section of the Province and from them we find that outside of the buried channel, hard rock rises to a considerable height above Lake Erie itself. I have shown elsewhere that this channel is in all probability a portion of the Preglacial outlet of Lake Erie, joined by various buried channels along the route; an outlet by this route would perfectly account for the outline of the shore of Lake Erie, and the greater depths of the lake from the region of Port Stanley, around Long Point, towards the Grand river. Whether this route is sufficiently deep to drain the deepest places in Lake Huron (750 feet) or not, has not been ascertained by actual observation, but certainly through the highest portion of the barrier, in the Dundas valley the buried channel is deep enough for all purposes.

Many valleys now partly buried were once tributary to this great river-system. In fact, the basin of Lake Erie abounds with them, as it was nothing more than a grand plane or prairie traversed by many streams cut into the soft rocks out of which most of the lake is excavated. Among the most important tributaries from the south were the Cuyahoga (whose valley, according to Dr. Newberry, is 228 feet beneath the lake surface); the Grand river of Ohio; and the upper Alleghany, which Mr. J. F. Carll, at the close of last year, demonstrated as flowing into Lake Erie near Dunkirk; as also some other rivers of Pennsylvania now sending their waters into the Ohio.

The Grand river of Ohio is interesting as being the portion of a magnificent and remarkably straight river now represented by portions of the valleys of the Monongahela, upper Ohio, Beaver (reversed), Mahoning (reversed, this Mr. Carll shows to have been the case) and Grand river (of Ohio) as recently pointed out be-

'e the American Philosophical Society. The upper Alleghany, ptying near Dunkirk, would be directly opposite the outlet of ı Erie basin as before described.

Excavations of the Lake Basins.— Having demonstrated that ;reat system of rivers extended through the various lakes, it comes apparent at once, that as the greater portion of all the ıat lakes (except Superior) are excavated mostly out of the re or less shaly rocks of the various regions, that the erosion atmospheric agencies would tend to wear the country into ıtly undulating basins, for only such are the bottoms of the ıat lakes. In fact, the lake bottoms have more uniform slopes ın the adjacent surfaces of the country exposed to atmospheric luences. Whether geological valleys first determined the position of the lake-basins, I do not venture to surmise, but one ng is certain that four of the great lakes, at least, are wholly oduced by erosion in almost horizontal rocks. Also the small ces of central New York have not had their position determined geological faults, as shown by Conrad, forty years ago.

Hypothetical glacier origin of the lakes.—The hypothesis that the kes were excavated by glaciers will now be briefly examined. ae cannot do better than give a summary of what Prof. Whitney n Climatic Changes) says with regard to the erosive power of ice. Ice *per se* has no erosive power." Glaciers are not frozen to eir beds. Ice permeated with water acts as a flexible body and n flow accordingly. In neither the extinct glacier regions of alifornia nor in the shrunken glaciers of the Alps will it be und that ice scoops out channels with vertical sides as water es.

"No change of form can be observed at the former line of ice. side from the morainic accumulations, there is nothing to prove e former existence of the glacier, except the smooth, polished rounded surfaces of the rocks, which have no more to do with e general outline of the cross-section of the valley than the arks of the cabinet-maker's sand paper have to do with the ape and size of the article of furniture whose face he has gone er with that material."

The most important work of a glacier is the scratching and ooving of surfaces. This may, however, be done by dry rubbing, d therefore isolated scratched stones or patches are no evidence. ae underlying rock surfaces may lose their sharpness, owing to

contained detritus in the ice, and become rounded. The grooved moraine is neither characteristic nor important. There is but little detrital material beneath Alpine glaciers, and this is the result of water more than ice. The only characteristics of ice action are striation and polishing. All floating ice shod with stones frozen in them will scratch surfaces over which they rub. The only glacial lakes that are formed are those where preëxisting valleys have been closed by morainic matter, but the waters will soon reopen these dams by running over them.

Such are the deductions of the late Director of the Geological Survey of California, a man who has had excellent opportunities for studying the action of glaciers. So far, Prof. Whitney's investigations are applicable to our great lakes.

Mr. George J. Hinde, F. G. S., one of the few geologists who has written from a Canadian standpoint, is an uncompromising glacialist. Because he has seen scratches in the northeastern end of Lake Ontario, and also others in a similar direction at the western end of the lake, therefore he asserts that Lake Ontario was excavated by a glacier. Dr. Newberry accepts his statement as proof, but considers that a Preglacial valley determined the direction of the continental glacier.

Mr. Hinde also asserts his belief that the buried valley of the Niagara river (by way of St. David's), as also that at Dundas is of glacier origin. It has been proved uncontrovertibly that the Dundas valley is a buried river channel. Also the St. David's valley is a bed of a preglacial or interglacial river.

Let us analyze the direction of the ice scratches in the neighborhood of the western end of Lake Ontario. I have not seen any (of very many sets), that are parallel with the axis of either the Dundas valley (except *possibly* one polished surface in the valley), or the axis of the lake, but always at considerable angles. In the region of Kingston, the prevailing scratches are S. 45° W. (Bell), and some others at S. 85° W., neither of which directions is parallel with the axis of the lake. Granted that Mr. Hinde observed scratches that were parallel with the axis of the lake, they of necessity would have been at angles with the submerged escarpment. If any glacier could have scooped out the basins of Lake Ontario, it left the summit edges of the Niagara escarpment as sharp as possible, and not planed off. Also, if it excavated the deep trough of the lake, it left the summit of soft Medina shales

over the harder Hudson river rocks of the submerged escarpment, beneath which are Utica shales. From Dundas to the Georgian Bay the face of the escarpment (Niagara) is less abrupt than south of the lake, but even there, not more than 50 feet of drift have been left at its foot, and this is mostly, if not altogether, stratified (excepting in channels now buried).

The observations of Prof. H. Y. Hinde, on the coast of Labrador, are here interesting. He has shown that *pan-ice*, at the present time, is polishing the sides of cliffs, and has been continuing its action whilst the coast has been rising several hundred feet. Even under the ledges of over-hanging rocks the action is now going on (a phenomenon which, if in the lake region, would be attributed to glaciers). Also, he had seen bowlder clay being formed at the present time by the action of *pan-ice* (frozen sea-water). This, with a thickness of eight or ten feet, gets piled up by the action of waves and wind, and consequently in the bays of the coast of Labrador it polishes rock bottoms to a depth of fifteen feet or more, below the surface of the water, and grinds off rough surfaces. I have frequently seen, myself, in northern regions, large bowlders transported by the ice to which they were frozen in the margin of small lakes.

From what has been written, it seems to me that the glacial origin of Lake Ontario does not rest on a single basis further than that ice scratchings (producible by either glaciers or icebergs, neither of which need be great erosive agents) are seen at various places about Lake Ontario, both above and below the water-level. The remarks applied to Lake Ontario hold good for the other lakes. Their topography strengthens the proofs that their origin cannot be accounted for by glaciers, because we find the islands at the western end of Lake Erie, or northern end of Lake Huron, polished and striated. All the facts appear to point to one series of causes — namely, the lake-basins are valleys of sub-aërial and fluviatile erosion, although their outlets to the sea have not been demonstrated.

Age of the River valleys.—The period of the river-valleys just described dates far back in geological time. If the explanations brought forward be wholly correct, then the date of the commencement of the valleys should be placed after the close of the Palæozoic time, as the valley of the Susquehanna, and of some of the ancient rivers entering the lake basins are partly excavated out of

carboniferous rocks, which had been previously elevated. This would agree with the older portions of the Mississippi river. However, the Great River Age did not culminate until the middle Tertiary times, as shown by the tributaries of the ancient Mississippi.

Origin of the Lakes themselves.—In the Ice Age the outlets of the valleys of the Great Lakes were closed by drift, apparently assisted by oscillations of the earth's crust, thus producing the lakes. Whether the fillings of the valleys were produced by glacier-action, by the agency of icebergs, or by that of floating pan-ice, a rational explanation might be given; but as this depends upon unsettled glacial geology, I will not here delay by entering into the discussion. However, there appears to be every evidence of an Interglacial epoch, when the greater portion of the present Dundas valley; the Niagara river, by the old buried channel of St. Davids; and many other valleys, everywhere in the lake region, were either reëxcavated in the drift, or originally opened; and that the second closing or filling of these valleys was not accomplished through any glacier action, but principally through the agency of pan-ice and currents.

Oscillations of the continent in the lake region.—Until recently my investigations bearing on the origin of the great lakes have been mainly based on the hypothesis that the closing of the basins was not occasioned by the elevation of the lake margins, by means of the local elevation of the earth's crust. This hypothesis then necessitates the existence of buried channels being outlets of the lake basins, which if their contained drift were excavated would restore the Preglacial drainage. My recent observations in New York and elsewhere have failed to obtain any proofs of the above supposition.

Outside of the region of the lakes, in the Red river valley, there are known, at least, two deep bore-holes far apart where the drift extends to a level below that of Lake Winnipeg, and indicates that if the drift were removed from the Red-Minnesota valley the drainage of some of the great lakes and rivers of the Canadian North West territories would flow to the Mexican Gulf (as first pointed out by General Warren) without the necessity of a local change of level. This fact extended to the lake regions strengthened my opinions as to the correctness of the above hypothesis.

Whilst the fluviatile origin of Lake Ontario is apparent, yet the

failure of demonstrating a drift-filled outlet for the basin (which is 500 feet below the level of the sea) has forced me provisionally to accept the hypothesis that the basin was partly closed by oscillations of the region, as strongly set forth in an able letter from Mr. G. K. Gilbert.

As an evidence of local oscillation, Mr. Gilbert has pointed out that the Irondequoit Bay, near Rochester, was excavated to the depth of more than 70 feet, and two miles wide, by streams of Post-glacial (or Inter-glacial) date, and subsequently submerged to the above depth. From this, his conclusion is that at the time of the excavation of this fiord-valley, the relative altitudes of the locality and the rock-sill over which the Lake Ontario discharges differed from their present status by more than 70 feet. Corresponding perfectly with Irondequoit Bay is Burlington Bay, at Hamilton, with a depth of 78 feet, with a closed beach across its mouth. From this and other local features, the surface geology of the Dundas valley (of which a large amount of information has been collected, but not yet worked out) would indicate a greater elevation, to the extent of more than 78 feet at the head than at the present outlet of the lake.

Let us consider for a moment the physical effect that would be produced upon the stratification by the subsidence of the northeastern portion of Lake Ontario and the upper St. Lawrence. The dip of the rocks at the western end of Lake Ontario is about 25 feet in a mile, westward of south. At the eastern end of the lake, I believe, it is somewhat greater. The deeper portions of the lake are more than 40 miles from its present outlet. Any local depression gradually extending northeastward from the deepest soundings of the lake, to even the extent of 25 feet in the mile, would lower the outlet by the St. Lawrence to an extent far greater than would be necessary to drain the lake, provided this change took place at a time of high continental elevation, thus producing a broad depressed valley. We know that the valley of the lower St. Lawrence is submerged to the depth of at least nearly 1200 feet. The rocky boundaries of the region could scarcely more than indicate this change of level as the dip of the rocks would pass from the condition of 25 feet in the mile or less to almost absolute horizontality, and we have no means of comparison. If, however, the elevations took place to the northward to a greater

extent than the southward, such as might be occasioned by a change of the centre of gravity of the earth, then the region to the southward of the lakes might be relatively sufficiently lowered as to permit the drainage to pass out by either the Mohawk or Seneca Lake valleys, which evidently during some portion of the Ice Age discharged waters from the expanded basin of the lake. The local oscillations would also greatly aid in the explanation of the closing of the outlets of the Upper Lakes which would be the most satisfactory if we could establish the greater northern elevation of the lakes over the southern.

With these remarks I will close. The present paper is exceedingly unsatisfactory owing to the fragmentary character of the facts that have been observed, and even only a portion of them have been worked out. A word of tribute must be paid to those whose works have paved the way to the present study. General Warren, in his discovery of the former great changes of the drainage of the Winnipeg basin, which concerns so large a portion of the continent, should fairly be placed as the father of Fluviatile Geology.

The records collected by and under the supervision of the Directors of the Geological Surveys of Ohio and Pennsylvania—Professors Newberry and Lesley—and those of Dr. Sterry Hunt, have been of the greatest value in working out this subject. To Mr. Carll belongs particular praise for elucidating the difficult problem of the former course of the Upper Alleghany into Lake Erie; and as his work, through the medium of the distinguished Director of the Pennsylvania Survey, led me to extend my studies beyond the western extremity of Lake Ontario and the Dundas valley, so I hope that this fragmentary paper may assist in giving prominence to the difficult subject of Fluviatile Geology, and correct what errors of observation and deduction that occur in the pioneering work of a department of science, even now almost untrodden, and yet one more than any other (though modified by others) explains the surface features of the lake region of the continent.

Evidence from the Drift of Ohio, Indiana and Illinois, in support of the Preglacial Origin of the Basins of Lakes Erie and Ontario. By E. W. Claypole, of Yellow Springs, Ohio.

The origin of the basins of the Great American Lakes is a problem which has roused considerable controversy. Two theories have been proposed to account for their existence, one of which ascribes them to the action of ice and the other to that of water. The former, the latest exposition of which may be found in the "Geology of Ohio," maintains "that the basin of Lake Erie in all its length and breadth as well as the smaller and yet deeper one of Lake Ontario, and the broader and far deeper ones of Lake Michigan and Lake Huron have been excavated by mechanical force from the solid rock."

"They are plainly basins of excavation dug out of sheets of rock that were continuous over all the area they occupy.

"Any one who will stand on the cliffs which overhang the lake in northeastern Ohio—cliffs which now rise 750 feet above the water surface—and will look over the sea-like expanse toward the Canadian shore, too distant to be visible, will get some realizing sense of the vastness of the mechanical effect which has been produced here, and an appreciation he could hardly obtain elsewhere of the resistless power of the agents which accomplished it."

"These agents were unquestionably *Water* and *Ice* and of the two that which was by far the most potent and that which alone could excavate broad boat-shaped basins such as these was Ice." (Geology of Ohio, Vol. I, p. 49). Again (Vol. II, p. 74). "There can be no doubt that the basin of each of the Great Lakes was produced by a local glacier."

Two arguments have been brought forward in support of this theory. It has been urged (Geology of Ohio, Vol. III, p. 47) that the beds of Lake Erie and Lake Ontario show clear marks of the action of glaciers. Smooth, polished and grooved rock-surfaces may be traced to the water's edge, consequently it is urged these basins must have been cut out by the ice. The fact, however, does not warrant the inference. Most geologists will allow that these lake beds were occupied by local glaciers, and that grooved and striated rocks may consequently be looked for, but

to assume that such markings are proof of the excavation of the whole lake bed by the ice is what logicians would call an illicit process of the first magnitude.

The assertion also, that no agent but a glacier can scoop out broad, boat-shaped basins even if admitted as a general truth for the sake of argument, has no application here. For it is not proved that the beds of our Great Lakes are of this shape. The evidence rather leads us to believe that these basins are connected by deep, narrow channels, possibly reaching to their very bottoms. In this case the argument founded on their form has no weight.

The two arguments in favor of the Glacial Theory of the Lake Basins being untenable, let us consider the leading objections to that theory.

1. There is no ground, judging from the analogy of existing glaciers, to attribute such enormous erosion to the ice. Glaciers can and do scoop out holes where the ground is softer or the motion swifter than usual, and on this fact is based Professor Ramsay's theory of Glacial Lakes — a theory which has by some been extended beyond all due bounds. In the Alps the slope of the glacier brook is steeper than that of the glacier, showing more rapid erosion, and though the wear and tear of the rocks beneath the ice during summer is considerable, yet they are protected from the most effective agents of meteoric abrasion, frost and rain. The immense erosion that has taken place in the Alps is due rather to water than to ice, and without wishing to deny or extenuate the amount of ice-erosion, we can find no evidence to justify us in exaggerating its effects as the theory in question demands.

2. The Drift in Ohio affords us no evidence in favor of the theory, but supplies one of the strongest objections against it. To make this evident a few preliminary statements are necessary. Lake Erie, in its deepest part off Long Point, is 200 feet deep, and its shores in Ohio rise about 750 feet above the lake. Lake Ontario has one sounding of 738 feet, and over most of its surface it averages about 400 feet. The excavation of these lake basins means, therefore, the removal of a mass of rock, in the case of Lake Erie nearly 1,000 feet thick, and in that of Lake Ontario scarcely less.

THE DRIFT IN OHIO.

Now we have in the Drift of Ohio a gauge somewhat rude, it is

true, but yet with limitations capable of being used for the purpose — a gauge of the amount of erosion accomplished by the ice during the glacial era. Acting on the axiom admitted in other cases in geology that deposition is the true measure of erosion, let us ascertain how far the Drift of Ohio warrants us in ascribing to local glaciers such enormous effects. The following facts and figures gathered from various sources, but chiefly from the geological report of the different states, may be of service in forming a true estimate of the abrading power of the ice sheet and of its accompanying local glaciers.

I must premise that the greater part of the beds of clay, sand, gravel and bowlders forming the Drift in Ohio, was in the ice age a ground moraine, that is, it was not carried on the surface of the ice, but shoved along beneath it. This is readily proved by the fact that it consists largely of material that has been moved only a short distance, the drift in any given county being largely composed of stone taken from the surface of the counties lying immediately north or northwest of it. Thus in Champaign county it is in great part made up of pebbles from the Water Lime group and in Greene county these are mixed with a large proportion of others from the Niagara and Cincinnati Blue Limestone, both of which formations crop out at a short distance to the northwestward.

The drift, moreover, contains immense numbers of the peculiar flat striated stones, so characteristic of a ground moraine. A certain proportion of them, but in southern Ohio not a large proportion, consist of Canadian Diorite or Greenstone. These Diorite pebbles are the only part of the material which has travelled any considerable distance, much of the softer material having been ground down into sand or clay.

The operation of the ice, therefore, consisted mainly in removing a certain thickness from the surface of the country in one place, and depositing it in another place at no great distance to the south or southeast. Consequently by measuring the depth of the material deposited we may obtain to a fair degree of accuracy the amount eroded.

For this purpose I first obtained figures representing the average depth of the drift over as many counties as possible in the state of Ohio; I then arranged the figures so obtained in columns, each column containing the names of an east-west row of

counties through the state. I thence obtained an average depth for each row of counties. The figures are given in detail below.

I

Ashtabula	58
Lake	104
Ottawa	53
Lucas	84
Fulton	116
Williams	127
Trumbull, thin.	
Geauga, not given in Geology of Ohio.	
Cuyahoga	20
Loraine, not given.	
Erie, thin.	
Sandusky	100
Wood	75
Henry	50
Defiance	51
Average	77

II

Mahoning	20
Portage	55
Summit	25
Medina	18
Huron	66
Seneca	60
Paulding	45
Average	43

III

Columbiana	31
Stark	55
Wayne	59
Ashland	55
Richland, not given.	
Crawford	40
Wyandott	42
Hancock	47
Allen	75
Putnam	45
Van Wert	40
Average	49

IV

Carroll, none.	
Tuscarawas	100
Holmes	53
Morrow	40
Marion	48
Hardin	62
Auglaize	75
Mercer	60
Average	[illegible]

V

Coshocton	100
Muskingum	63
Licking, not given.	
Delaware	18
Union	28
Champaign	10
Logan	11
Miami	50
Shelby	100
Darke	100
Average	56

VI

Fairfield, not given.	
Pickaway, not given.	
Franklin	50
Madison	60
Greene	50
Clarke	90
Montgomery, not given.	
Preble	29
Average	54

VII

...te	55	Butler, not given.	
...on	55		
...en	30	Average	47

VIII		IX	
...lton	55	Brown	30
		Clermont	30
		Average	30

AVERAGE DEPTH OF DRIFT IN THE STATE OF OHIO.

		feet.			feet.
... group of Counties	11	838	Eighth group of Counties	1	55
...d " " "	7	289	Ninth " " "	2	60
. " " "	10	489			
...h " " "	7	438			
" " "	9	519		54	) 3048
" " "	4	220			
...ith " " "	3	140			56

rom an examination of these figures two conclusions may be rn.

That the drift deposits of Ohio thin out towards the south hey recede from the water-shed.

That their average depth does not exceed fifty-six feet.

ow as I have shown above that this drift material is only the ind moraine of the ice-sheet, it follows that the erosion pro-d by the ice-sheet did not exceed fifty-six feet.

n objection will be urged here which must be considered. It be said that so much of the drift material has been washed y since its deposition, that the thickness here given must be below the truth. This objection, however, though real, does affect the argument and may be met in two ways.

The valley of the Ohio at Cincinnati is known to be filled with ; to the depth of nearly 100 feet. Let us assume that the same eme depth prevails along the whole channel of the river in the e, about 400 miles, and that the bed of the Ohio averages one in width. This will give us an area of 400 square miles filled to pth of 100 feet with material washed from the drift beds of this e. The Drift-area of that part of Ohio lying within the basin he river is about 20,000 square miles, and if the whole of this erial be replaced on the south slope of the drift area, its sur- would be raised by an average of twenty-four inches only.

Admitting that some amount of material has been washed 1 the southern slope of the drift area into the river, and from

northern slope into the lake, it is perfectly clear that no appreble amount has been carried away from that part in which the ter-shed of the state lies. This part of its surface consists gely of swamp and peat moss dotted with innumerable lakes d ponds, many of them without an outlet. Dr. Newberry says at he has mapped more than a hundred of these lakelets within radius of twenty miles (Geology of Ohio, Vol. I, p. 46). This s the region where drainage has not been reëstablished since the retreat of the glacier, and the uneven surface then left still remains without appreciable change. In fact, the streams do not know which way to flow, and the turning of a sod or the casting up of a bank may decide whether the Ohio or Lake Erie shall receive their waters. In this region of imperfect drainage where the outflowing streams, if any, have not yet cut down the barriers of the lakelets, it is perfectly clear that no appreciable amount of erosion has taken place.

If it were otherwise, these lakes would long ago have been drained dry as has happened in lower parts of Ohio. We may, therefore, infer that along the water-shed, the depth of the drift at present is the same or nearly the same as when deposited.

THE DRIFT OF INDIANA.

I have been unable to examine the evidence supplied by the Drift of Indiana as thoroughly as that from Ohio. The Geological Survey of Indiana often fails to give information on this point. Such figures, however, as can be collected, fully bear out the conclusion above expressed.

Artesian wells bored at various points show the thickness as follows: "At Michigan City 172 feet, at New Buffalo in Michigan, near the state line 212 feet, at South Bend 92 to 103 feet, at Elkart 125 feet, and at Fort Wayne 88 feet. At Indianapolis in the central part of the state, the drift is from 80 to 90 feet thick. From this point south it rapidly thins out." (Geology of Indiana, 1874, p. 9).

Arranging the figures which I have been able to obtain as those from Ohio were arranged, we have the following results.

In the northern belt of counties the average of three measurements gives 132 feet as the depth of the drift. Three measurements in the belt of counties next to the southward give 97 feet. One measurement in Jackson county gives 60 feet, and four in counties lying along the Ohio river give only 29 feet.

We cannot attach the same value to these figures as to those from Ohio, but even here we find no enormous depth of glacial matter, the average for all the counties given being only 78 feet.

THE DRIFT IN ILLINOIS.

Turning now to the state of Illinois we obtain more satisfactory results. Thanks to the care of those engaged on the Survey, I have been able to collect a large number of figures useful for the purpose in hand. I have found measurements of the depth of the drift from 58 counties. Arranging these in five groups beginning with the most northerly, I have averaged the thickness of the glacial deposits in each group and the figures are given below.

I

	feet.		feet.
Jo Daviess	50	Dekalb	75
Stephenson	30	Kane	75
Winnebago	15	Dupage	75
Boone	85	Whiteside	44
McHenry	70	Lee	45
Lake	70		
Carroll	53	Average	62
Ogle	125		

II

	feet.		feet.
Rock Island	45	Marshall	10
Henry	75	Henderson	55
Bureau	130	Warren	45
La Salle	100	Knox	35
Kendall	75	Peoria	70
Grundy	62	Woodford	85
Will	125	Iroquois	62
Kankakee	62		
Mercer	30	Average	65
Stark	35		

III

	feet.		feet.
McDonough	50	Mason	94
Fulton	45	Logan	94
Tazewell	94	Champaign[1]	220
McLean	94	Vermilion	84
Adams	137	Menard	70
Brown	95		
Schuyler	100	Average	85
Cass	70		

[1] This is probably a measurement in the buried channel of some preglacial river and should not therefore be included in finding the average.

IV

	feet.		feet.
Pike	70	Calhoun	65
Scott	50	Greene	50
Morgan	60	McCoapin	60
Sangamon	65		
Edgar	100	Average	65

V

	feet.		feet.
Clinton	27	Jackson	20
Marion	40	Alexander	25
Washington	16		
Perry	30	Average	29
Monroe	50		

AVERAGE DEPTH OF DRIFT IN THE STATE OF ILLINOIS.

First Group of Counties	13	812 feet.
Second " " "	17	1101 "
Third " " "	12	1027 "
Fourth " " "	8	520 "
Fifth " " "	7	208 "
	57	) 3668
	Average	64

AVERAGE DEPTH OF THE DRIFT IN THE THREE STATES, OHIO, INDIANA AND ILLINOIS.

Ohio	54 counties	3048
Indiana	11 "	864
Illinois	57 "	3668
	122	) 7580
	Average	62 feet

It thus appears that the glacial erosion of Illinois measured by the same standard, that is, the amount eroded, only reached 64 feet, exceeding but by a slight amount that obtained for the state of Ohio.

Averaging lastly the results obtained for the three states of Ohio, Indiana and Illinois, it appears that glacial erosion did not exceed 62 feet.

I am aware that this conclusion is at variance with the opi ions of many geologists, but no other is possible from the pre ises. It may be well to remark here, that being drawn fr figures obtained in Ohio, Indiana and Illinois, they cannot leg mately be used outside of that territory. Glacial erosion in o districts may have been more or less, but with that the pre argument has nothing to do.

two remarks may be made here tending to show that so
aount of erosion is not unreasonable. If we adopt the
vocated by Dr. Croll, and remember that Ohio, Indiana
is were near the southern edge of the ice-sheet, we must
t its duration in these states was comparatively short.
going into details we may assume that it can hardly
eded 20,000 years at the utmost. Putting these figures
we find that the erosion of 62 feet in 20,000 years
to about one foot in 360 years or about one inch in 30
at is, one-thirtieth of an inch annually; an amount
pears ample or even excessive when the nature of the
ducing the erosion is considered.

y further call the attention of those geologists who at-
great an effect to the action of the local glaciers to the
of the Great Silurian Escarpment of Ontario and New
ich stretches like a rampart, 300 feet in height, along
shore of Lake Ontario, round its western end and thence
tward through the Manitoulin islands and Mackinac
round the western shore of Lake Michigan. Standing
he path of the ice and exposed to its full pressure in a
where the duration and the thickness of the ice-sheet
ter than in Ohio, it survives as a monument to warn us
n excessive estimate of its erosive power. Had the Con-
glacier been capable of performing the work often at-
to it, it is impossible to doubt that the Niagara escarp-
st have been totally swept away from the face of the

ce more. A moment's consideration of the position of
ler Clay, as it is termed, will lead the mind in the same
This is a sheet of tough blue clay and stones, ad-
all to have been formed underneath the glacier. The
l over it without disturbing or displacing it. Hence it
a protector to the ground beneath it, and wherever this
oraine is found we know that during some part of the
abrasion of the underlying rocks took place. It occurs
ry large portion of the drift area of these states, espec-
he northern part, and its presence must have greatly re-
erosive effect of the glacier.

sely avoid entering here into any details concerning the
a, such as the number of times the ice-sheet existed, its

extent, and the effect of interglacial warm periods, because such considerations would have little or no effect on the line of argument developed in this paper.

Returning now to the main line of argument, we reach the following conclusion. The excavation of the beds of Lake Erie and Ontario, as I have before said, implies the removal of rock to the depth in some places of nearly 1,000 feet. Now I have shown from the evidence supplied by the drift that the continental ice sheet during its whole existence and in spite of its enormous mass, did not remove more than sixty-two feet from the surface of the country. It is impossible, therefore, to admit that small and temporary local glaciers on the sites of Lake Erie and Ontario were capable of excavating those beds to their present depth. To assert this in face of the evidence is to assert that the effect is increased by diminishing the cause, and to maintain that these small short-lived local glaciers accomplished what the massive, enduring continental ice-sheet was unable to effect.

3. A third objection to the glacial theory of the lake basins may be urged to the same effect. If the bed of Lake Erie had been excavated by a local glacier, the material so excavated would be found at the end of the glacier as a terminal moraine. But it is not so found. The area of Lake Erie is in round numbers 10,000 square miles, and the depth of the excavated basin in which it lies varies from three to nine hundred feet. The area in Ohio, Indiana and Michigan, over which the moraine matter would be spread, equals that of the lake, consequently according to the glacial theory we should look for drift material at the southwest end of the lake from three to nine hundred feet in depth. But the drift in this region does not exceed in thickness that of the northern tier of counties in Ohio, so that it is evident that the matter from the bed of the lake was not carried westward.

4. A fourth objection may yet be urged not less forcible than the other three. The existence of local glaciers in the basins of Lakes Erie and Ontario before and after the presence of the continental ice-sheet has been conceded, but the existence of these local glaciers implies the previous existence of the lake basins. Local glaciers exist on low grounds and had the lake basins not existed, none could have been formed. Not only must they have existed, but they must have been almost what they are at present. Had they been only deep narrow gorges the ice would

ave filled them with drift material and passed over them without roducing a change. This has happened in many places. Deep reglacial river channels have been filled so that their existence an only be proved by boring. To have become the beds of local laciers, these lake basins must have been the broad open valleys which they now are. In no other case could they have been able o deflect the projecting tongues of the ice-sheet. They were the auses and not the effects of these glaciers and to reverse this rder is to mistake the effect for its cause.

THE RIVER THEORY.

It thus appears that the glacial theory of the origin of the beds of Lakes Erie and Ontario involves such impossibilities and absurdities that it is altogether untenable. We come, therefore, to the consideration of the second which may be termed the River Theory. This theory which the writer enunciated at some length n the "Canadian Naturalist" for April, 1877, maintains that the beds of these great lakes were formed by an ancient river flowing through the region — that they are in fact only the broader portions of its chamnel, the narrower parts being filled with drift— and that the glaciers had little to do with their formation, though they occupied them for a time and left upon them the usual traces of glacial action.

Evidences of the existence of this ancient river are abundant, and new ones are constantly coming to light. So far as yet traced, its course was as follows: Having its sources in the Great Huron plain or valley, it flowed by some channel not yet fully proved, into that of Erie, thence into the Ontarian valley, and by a deep and now buried channel partly traced, probably through the state of New York, as suggested by Dr. Newberry and others, into the Atlantic of that day by the gorge of the Hudson. On this view the lake beds are valleys made by the ancient river and its tributaries as during their long existence they cut down the basin in which they flowed and carried the materials to the ocean. No cataract probably existed between the Erian and Ontarian basins. The river had cut it down as must in the end be the case with all cataracts. The river may have been navigable for a thousand miles, but there was no one to navigate it except, possibly, palæolithic man in almost the lowest stages of barbarism.

It is right to notice here one or two objections which have been urged against this theory. It has been said (Geol. of Ohio, vol. 3, p. 46) that rivers never excavate such a beaded channel as is supposed, consisting of broad valleys where the rocks are soft and of narrow gorges where they are hard. "This," it has been said, "has no warrant in any facts yet observed on the earth's surface."

In opposition to this assertion Elisée Réclus says (The Earth, p. 182) "some valleys present a succession of rounded basins separated from each other by narrow passes." "Wherever the materials operated upon are of analogous composition and thus everywhere present an equal resistance to the action of water the latter adopts a meandering course. On the contrary, where the rocks consist of strata of unequal hardness or are traversed by obstructing walls, the water is compelled to spread out into a lake-like accumulation in the mean time eating away its banks in a lateral direction." "In this way there has been formed a *series of basins* one above another linked together by *narrow defiles* through which pours the mountain torrent."

A very slight acquaintance with the Physical Geography of rivers will supply abundant examples for the refutation of this objection which could hardly be urged after due consideration of the subject.

One other objection requires a passing notice. It has been said by some that if these Lake Basins are only parts of the course of a preglacial river they must be connected by deep channels capable of draining them to the bottom. To this we may reply that evidence which has been obtained during the past few years leads to the belief that these Lake Basins are connected by deep narrow channels. The depth of these channels is not yet fully known, but in some cases it is known to exceed 400 feet. The borings for oil or for salt which have revealed these facts have not been conducted with a scientific purpose. Their full capacity of yielding evidence on this point has not therefore been developed. Some of them have been stopped before the rock was reached and we are not sure that any of them were sunk in the deepest parts of the channels. For all that we know therefore to the contrary these channels may be deep enough to drain the Lakes to their very bottom and the objection above mentioned, resting as it does entirely on negative evidence, is not at present of any moment.

SUMMARY.

Summing up therefore the argument here developed we find:

1. That the glacial Theory of the origin of the Basins of Lakes Erie and Ontario rests on evidence altogether insufficient.

2. That it is met by the following unanswerable objections.

a. The erosion demanded is not justified by the phenomena of modern glaciers.

b. The erosion demanded is far beyond what the Drift deposits of Ohio, Indiana and Illinois warrant us in attributing to any local glaciers or even to a continental ice sheet.

c. The material excavated is not found where, on the theory, it should be found.

d. There could have been no local glaciers had the Lake Beds not previously existed to hold them.

3. That the River Theory of the origin of these Lake Basins is not beset by any similar difficulties.

4. That these two Lakes and perhaps Lake Huron also must be regarded as the broad open portions of the course of a preglacial river whose narrower parts are now filled with Drift and concealed.

Traces of the channel of this river may be found in many places. Opposite Detroit the rock is 130 feet below the surface of the water. Near Port Stanley it is almost 200 feet. By one of these channels the waters of the Huron Valley may have reached the Erie Basin. Dr. Spencer believes that he has found the old channel by which it flowed into the Ontario Basin along the Grand-River and down the Dundas Valley into Burlington Bay. A Cliff apparently marking the continuation of the river and now sunk beneath the waters runs parallel with the South Shore of Lake Ontario passing under Lock No. 1[2] Port Dalhousie and continuing to the neighborhood of Oswego. The lower course of the channel is indicated, if not traced, among the Salt borings near Syracuse, N. Y., but farther than that its direction is at present uncertain. So conspicuous a feature in the preglacial geography of North America should however have a name and I therefore suggest that it be called the RIVER ONTARIO.

[2] See paper by the author in the Canadian Naturalist, Vol. IX, No. 4.

Typical thin sections of the Rocks of the Cupriferous Series in Minnesota. By N. H. Winchell, of Minneapolis, Minn.

In northern Minnesota the cupriferous rocks, when crystalline, consist of two distinct types. One series is *igneous*, and one is *metamorphic*.

The former may be broadly comprehended under the term *dolerite*, as defined by Prof. J. D. Dana. The most frequent representative of this group is the rock gabbro, consisting essentially of labradorite, augite and titaniferous magnetite. It produces the dark-colored and heavy rocks of the shore, is seen as layers alternating with the non-crystalline and sub-crystalline layers of the other group, and as massive, mountain-like elevations. It is often basaltic. On weathering, it decomposes and becomes greenish when near the water, but brownish when at higher elevations. It is often amygdaloidal, furnishing various zeolitic and other minerals. It has a very intimate, and yet very distinguishable association with the rocks of the other group; but in general it is the most conspicuous rock of the cupriferous series, causing the most of the salient features of the coast, and the prominent elevations of northeastern Minnesota. When in contact with the sedimentary beds, the rocks of the igneous group are but slightly affected by the interpenetration of the minerals of the other group. Yet in some instances isolated pieces of the sedimentaries have been embraced in the igneous rock, and so completely fused with them, that the minerals that otherwise characterize each are closely mingled over small intervals.

The rocks of the second or metamorphic group, on the other hand, are, in nearly all cases, of a reddish color. They show all stages of metamorphic change—from red sedimentary shale and sandstone to red felsite and syenite. The minerals that are invariably found in this rock, when completely crystalline, are quartz, orthoclase and hornblende. The beds from which these crystalline red rocks were derived are seen interstratified with regularity with the rocks of the other group. But when these red rocks are crystalline or subcrystalline, the alternation is less evident. The alternation in this changed condition is less frequently seen in horizontal layers, but rather appears in sudden vertica

replacement. In some places they appear to have had a great thickness, and they constitute, in their changed condition, some of the most interesting features in the geology of the north shore. The red felsite of the Great Palisades containing crystals of adularia, which is underlain by a very characteristic dolerite of the igneous group, and penetrated by numerous dykes from it, can be traced, in varied steps, on the one hand to its original condition, a shale of the Potsdam formation; and in the other direction, through step after step of metamorphic change, to a hard crystalline rock of a red color and of a granular texture consisting essentially of orthoclase, quartz and hornblende. It is not always possible to observe a continuity of bedding from one extreme condition to the other. The circumstances of upheaval and metamorphism have generally been unfavorable for that. Some of the links are wanting in nearly every series of observations, but they are such as are supplied at other places — such places also failing to show other links. It may be supposed that it is necessary to make a perfectly connected series of contiguous observations, on a rock, *in situ*, changing from step to step, without interruption of the beds by dip or other cause, in order to establish the series; but such is not the case. When it once becomes evident that certain mineral associations are constant, if a part of these associations are observable, the rest may be relied on. When it is understood that there are two great sources of crystalline rock, the igneous and the metamorphic, and some of their related phenomena are established, such established phenomena are indices to show the origin of other new phenomena. Such new phenomena may again be taken in the same way to point others, and these again others. So at last a whole family of phenomena can be grouped together, although at no place can a connected series of all the phenomena be observed. In that manner, step by step, the lithology of the crystalline copper-bearing rocks can be reduced to two series. When these microscopic phenomena are in concord with and are affirmed by the field geology, as is the case on the north shore of Lake Superior, the true solution of some very interesting questions is found. The rocks of the second series, the result of the crystallization of the Potsdam shales and sandstones, are found to occupy a large area in the extreme eastern portion of Minnesota, northeast of Grand Marais,

while those of the first series seem to prevail along the shore, and to cause mountain ranges at some distance from the lake.[1]

The following brief descriptions are intended to give a general idea of the two groups.

(a) *Rocks of the Igneous Group.*

1. (Survey Number 1.) Gabbro, "Duluth Granite." From Rice's Point, near Duluth; the rock of a low mountain range. Contains labradorite and changed augite, the latter being uralitic; also titaniferous magnetite.

2. (Sur. No. 49). Behind the M. E. Church, Duluth. Contains augite, plagioclase, and magnetite, with viridite and ferrite.

3. (Sur. No. 53). East Duluth. Coarsely crystalline. Contains plagioclase, augite, magnetite and delessite, also some chrysolite and biotite. In some places this rock also shows orthoclase, making it resemble No. 5 of the Survey numbers.

4. (Sur. No. 90). From the E. point of Sucker bay. Contains plagioclase, augite, magnetite, chrysolite.

5. (Sur. No. 113). Labradorite rock, from masses included in gabbro at Split-rock point.

6. (Sur. No. 116). From the point half-way between Split-rock point and Two Harbor bay. Shows a basaltic structure. Contains plagioclase, augite, magnetite, viridite, opacite, and an occasional grain of biotite.

7. (Sur. No. 123). From the bluff east of Castle Danger; a dolerite, containing plagioclase, augite, chrysolite, magnetite, and viridite.

8. (Sur. No. 126). This is the rock that furnishes the black sand at Black beach, a few miles W. of Beaver bay, one-half mile up the creek. It seems to consist of plagioclase (labradorite?) hypersthene, and magnetite, making the rock hyperite. The metalloidal surfaces of the crystals in this rock resemble those of the rock of Encampment Island.

9. (Sur. No. 128). Section of a large crystal of labradorite, from masses embraced in gabbro at Beaver Bay.

10. (Sur. No. 141). Dolerite: first rock east of the Great Palisades, (lies below the Palisades?). Has augite, plagioclase, magnetite, viridite (and biotite?).

11. (Sur. No. 160). The rock that protects Little Marais on the east: plagioclase, augite, magnetite, also hematite and ferrite.

[1] A series of fifty thin sections with samples of the rocks from which they were prepared, were exhibited, and examined at the table by means of polarized light, on a microscope kindly loaned for the purpose by Mr. W. H. Bulloch of Chicago, Ill. They were numbered successively from one to fifty, the first twenty-one being of the igneous group, and the next twenty-one of the metamorphic. The last eight, from forty-three to fifty, were selected to show a mingling of the minerals of both groups in one rock. The samples of rock were numbered in blue shellac with the field number of the survey. The labels attached to the slides name the most evident and abundant of the minerals seen in each, as they have been identified by the writer.

12. (Sur. No. 199). The rock of Grand Marais Harbor; plagioclase, pyroxene, and magnetite; hematite, ferrite, apatite.

13. (Sur. No. 200). Cupriferous gabbro; from N. W. ¼ Sec. 24, T. 61, R. 1. W. (up Fall river); plagioclase, augite (diallage?) magnetite, viridite, ferrite. There are thin sheets of native copper disseminated through the mass of this rock. The rock, as a dyke, cuts a rock like that of the Great Palisades — an amorphous, red, but slightly porphyritic, orthoclastic felsite.

14. (Sur. No. 221). From a short distance east of the Brulé river; plagioclase, diallage and magnetite; coarsely crystalline.

15. (Sur. No. 229). Dolerite; Red-rock bay; runs under the E. Palisades.

16. (Sur. No. 261). From the hill 520 feet above the lake on N. E. ¼ Sec. 25, T. 64, R. 7 E., represents the rocks of the hills about Grand Portage; a dolerite, consisting largely of diallage, plagioclase and magnetite, with chrysolite and a little prehnite.

17. (Sur. No. 275). From the dyke at the brink of Pigeon river falls; augite, plagioclase, magnetite and chrysolite?

18. (Sur. No. 291). From the extremity of Pigeon point peninsula; like No. 1; gabbro; plagioclase; diallage, chrysolite, viridite, and magnetite.

19. (Sur. No. 297). Gabbro(?) from the English Rapids, on the international boundary, near Grand Portage; associated with the Animikie Group; augite, plagioclase, magnetite.

20. (Sur. No. 637). The labradorite rock of Beaver Bay from masses embraced in gabbro.

21. (Sur. No. 664). Augite, plagioclase, magnetite; from a ridge a little more than two miles north of Horse-shoe Bay.

(b) *Rocks of the Metamorphic Group.*

22. (Sur. No. 1 B). Brownish-red, hornblendic syenite, associated intimately with No. 1. Duluth. Contains orthoclase (changed), quartz, hornblende (often changed), magnetite, apatite and ferrite.

23. (Sur. No. 3). Brownish or reddish rock. In the Rice Point range of hills; suburbs of Duluth; intersection of 5th Av. E. and 7th St.; abruptly separated from No. 1 A by a compact dyke; consists essentially of orthoclase (which makes it sparingly finely porphyritic), quartz, and hornblende. It also has apatite, magnetite and ferrite.

24. (Sur. No. 7). Brownish-red rock, fine-grained. Between 2nd and 3rd avenues, Duluth, near the lake. Tabular and imperfect crystals of flesh-red feldspar (orthoclase), viridite (from hornblende), magnetite, apatite, and a small amount of quartz.

25. (Sur. No. 8 A). Rock inclusion in Survey No. 8; very fine-grained gray rock, showing fine crystals of red feldspar, probably orthoclase, but for the most part this is an amorphous, felsitic mass embracing grains of magnetite and viridite, with other minerals.

26. (Sur. No. 8 B). Porphyry, Duluth. Has orthoclase, chlorite, magnetite and other minute grains; plainly a rock resulting from the metamorphism of the sedimentary beds.

27. (Sur. No. 8). Sub-crystalline, showing much magnetite and quartz; also undistinguishable grains, some of which are probably viridite, hæmatite and pyrite, in a felsitic paste.

28. (Similar to Sur. No. 8 C). Finely sub-crystalline, nearly destitute of free quartz, brownish or reddish. Duluth.

29. (Sur No. 17). Outwardly and macroscopically, a thin-bedded red shale or sandrock; east of the Brewery creek, Duluth, at the lake shore. In thin section shows a rusty felsitic base with much magnetite or menaccanite, and viridite; the whole clouded with amorphous inclusions.

30. (Sur. No. 33 B). Metamorphic shale. Duluth, at the lake shore; has a felsitic (?) ground-mass, showing a porphyritic orthoclase; magnetite, viridite, hæmatite, apatite, quartz.

31. (Sur. No. 67). Metamorphic shale. London, near Duluth.

32. (Sur. No. 117). The reddish vein from Two Harbor rock, Two Harbor bay. Quartz grains and geodic aggregations, in a reddish orthoclastic base.

33. (Sur. No. 124). Rock of the west bluff, at the entrance to Beaver bay. Quartz grains with impurities, in a reddish, dimmed base that seems to be orthoclastic, magnetite, apatite.

34. (Sur. No. 127). Hardened gray shale, from near the mouth of Beaver creek. Quartz grains can be seen in an amorphous, apparently felsitic base.

35. (Sur. No. 129). Similar to No. 127, but porphyritic with orthoclase and translucent grains like adularia; a few rods N. E. of the mouth of Beaver creek.

36. (Sur. No. 134). Quartz, orthoclase, magnetite. The quartz makes up about one-quarter of the whole, the orthoclase perhaps two-thirds, but the magnetite is only in occasional grains. This is from the third island east of Beaver bay.

37. (Sur. No. 136). Is from opposite the fifth island east of Beaver bay. Wholly crystalline red rock, containing quartz, orthoclase, and much of a green mineral that is probably changed hornblende. This green mineral is generally fibrous, with spreading, fan-shaped radiations, but not always. Sometimes it shows simply a green felted polarization, always green at +.

38. (Sur. No. 138). The rock of the Great Palisades; an orthoclastic felsite, porphyritic with adularia, resembles Sur. No. 129.

39. (Sur. No. 201). Orthoclastic felsite, with a few distinct crystals of orthoclase and adularia or sanidin. This is the Palisade rock from the Copper mine up Fall river.

40. (Sur. No. 264). From the same place as Sur. No. 263, east side of Wauswaugoning bay. Quartzite fragment embraced in gabbro, quartz and hornblende in a cement of felsite.

41. (Sur. No. 265). From the upper part of Sur. No. 263, where in contact with the metamorphic rock. Results from the inclusion of a fragment of the sedimentary beds in the igneous. Contains quartz, orthoclase and hornblende, with ferrite and graphite.

42. (Sur. No. 668). The "red granite" of the region northeast of Grand Marais. Consists of orthoclase, quartz and changed hornblende with magnetite.

(c) *Mixed Igneous and Sedimentary Rocks.*

43. (Sur. No. 1 A). Gabbro. Duluth. Rice point range, near a contact with No. 1 B. Contains labradorite, uralitic augite, and titaniferous magnetite. Some of the augite is changed toward viridite. Orthoclase in occasional grains.

44 and 45. (Sur. No. 5). At the depot, Duluth; labradorite, augite, quartz, magnetite, orthoclase, apatite. The augite is sometimes viriditic and sometimes uralitic.

46. (Sur. No. 6). Labradorite, augite, magnetite, viridite (perhaps a result of change from hornblende) and an occasional grain of quartz. This is a dark-green, heavy, homogeneous rock, coarsely crystalline, near the bay, in front of the Clark House, Duluth. The igneous type predominates.

47. (Sur. No. 46′). Rock showing the contact between the igneous and the metamorphic groups, from Duluth. One side of the section is red, and contains: quartz in perfectly distinct and abundant grains, making up about one-third or one-half of the whole; orthoclase, which is next in amount to the quartz, these two making up most of the section; apatite in small quantity; magnetite; ferrite and hornblende (?), in a few brownish-green or greenish grains which, on rotation at +, change from bluish-green to yellowish-green, and back again.

The other side is darker, and contains: plagioclase, augite grains (altered to uralite) disposed among the plagioclase, and in larger grains, sometimes fibrous and sometimes broken irregularly; magnetite in much greater amount than in the red rock; ferrite in small quantity.

48. (Sur. No. 263). Contains the minerals both of the igneous and the sedimentary beds. From the E. side of Wauswaugoning bay. Its position and limited extent show its accidental occurrence, and merely local importance. The igneous minerals are labradorite and magnetite. The sedimentary are quartz, orthoclase and hornblende. Apatite spicules penetrate them all.

49. (Sur. No. 282). From the porphyritic main axis of the north part of Susie island, near Pigeon Point. Contains plagioclase, orthoclase, hornblende, magnetite, quartz, pyrite.

50. (Sur. No. 675). The rock of the top of Brulé mountain, north of Grand Marais. Orthoclase, quartz, hornblende, plagioclase (?) magnetite, viridite, ferrite, chrysolite, apatite.

OBSERVATIONS.

The orthoclase of the metamorphic rocks is more readily disseminated through the igneous rocks than the triclinic feldspars of the igneous are through the metamorphic.

The magnetite of the igneous, as at Mayhew lake, where it forms extensive beds of iron ore, may be derived from the exceedingly ferruginous sedimentary rocks. Magnetite seems to be always present in the crystalline metamorphic, and is probably the result of partial deoxidation from the indigenous hematite that gives them their color. Chemical analysis of the red shales would perhaps show the presence of titanium with the iron before metamorphism, and would indicate the correctness of this hypothesis. Wherever titanic iron is found in Minnesota, it is where the two series of rocks are in contact or proximity, so far as observed.

A fine shale becoming heated and slowly passing toward fusion will first show crystals of the easier fusible minerals, *i. e.*, orthoclase before quartz; and if the change stops there the resulting rock would be a non-differentiated (or felsitic) ground mass sprinkled with porphyritic feldspar crystals, all the siliceous parts being embraced in the ground mass. On the other hand, a fused sedimentary rock, passing to solidification, will first show crystals of the least fusible minerals, *i. e.*, quartz before orthoclase, and hence will contain more or less perfect crystals of quartz, cutting the sides of the later formed orthoclase. Hence the same metamorphic rock may show no quartz in one stage of metamorphism, but an abundance of free quartz in another. If the rock at first held grains of free quartz they would still remain in the former case, and would be an evidence of its original sedimentary source, and in the latter they would of course be subject to re-crystallization.

The term felsite, as used in this paper, is intended to express a non-differentiated, somewhat metamorphic rock, derived from shale, without any reference to the origin of felsite rocks described in other places.

THE BEREA GRIT OF OHIO. By EDWARD ORTON, of Columbus, Ohio.

THE geological place of the Waverly group of Ohio is no longer a disputed question. It has been proved to be of Sub-carboniferous age so far at least as the bulk of the strata, included within its generally received limits, is concerned. Some confusion, however, still exists in regard to its boundaries and subdivisions and as to the range and extension of the series through the state and into adjacent territory.

Within the last two or three years, I have spent such time as I could control in studying this series as it is shown in Ohio, and within this period I have for the first time obtained, in regard to its leading elements at least, a clear and self-consistent view. The construction that I have been led to give to the facts differs in some details from that which has heretofore been made public. I wish to bring before the Association a few results that I consider fully established as to this series, and which seem to me indispensable to a correct interpretation of this important division of our geological scale.

The Waverly group derives its name from the town of Waverly in the lower Scioto valley. A ledge of valuable building stone that occurs at this point, and below it in the valley, began to find its way to the central portions of the state more than fifty years ago, under the name of the Waverly sandstone. The name *Waverly* was gradually extended to the shales below the sandstone and to the shales and sandstones above, until the whole series between the great black shale that crosses the state from north to south, and the Carboniferous conglomerate or the lowest Coal Measure rocks came to be included in a *Waverly group*.

Questions as to age, equivalence and continuity soon arose and decided differences of opinion were developed among the geologists who were dealing with the series in whole or in part.

In considerable portions of the group, and this too in the lower and more critical portions, but few fossils had been found, and the stratigraphical connections were obscure and uncertain. A great advance was made towards a true order when, about ten years since, Dr. Newberry announced the discovery of Chemung fossils in the upper portion of the *Erie shale* of northern Ohio, and of

fossils of distinctly Carboniferous type in the *Cleveland shale* of the same district. At the boundary between these two well characterized strata, he fixed the line of division for the Ohio scale, between Devonian and Carboniferous time.

To give this statement its proper significance it is necessary to review briefly the geological sequence of a part of the strata of northern Ohio and the classification made of them by Dr. Newberry.

A stratum of black shale, ranging from 150 to 350 feet in thickness, above the Corniferous limestone, but separated from it by ten to thirty feet of blue or calcareous shale, was named by Newberry the *Huron shale*, a designation adopted from Dr. Alexander Winchell's classification of the Michigan series. This black or Huron shale is almost entirely destitute of animal fossils through the greater portion of its extent, but the calcareous shale at its base is sometimes highly charged with fossils, the fossils being, according to Newberry, exclusively of Hamilton age. This thin and somewhat uncertain stratum is counted by the same geologist as the true and only representative of the Hamilton group in Ohio. I believe this stratum to be the same which Professor N. H. Winchell has named the *Olentangy shale* in central Ohio, where however it is very poor in fossils.

The Huron shale was further described as covered in northern Ohio by the *Erie shale*, a mass of blue shale that has a thickness of 100 feet or thereabouts in Cuyahoga county, and rapidly increases in thickness to the eastward, so that 1000 or even 1200 feet are claimed for it on the Pennsylvania line. It was in the upper portions of this Erie shale that the fossils were found which were clearly of Chemung age.

This *blue* shale, covering a *black* shale, as will be remembered, is itself overlain by another bed of black shale, the Cleveland shale of Newberry, and described by him as ranging from twenty to sixty feet in thickness, and as containing numerous fossils, among which he specially recognizes the scales of *Paleoniscus* and the teeth of *Cladodus* and other carboniferous sharks. This last division, viz., the Cleveland shale, he makes the base of the Waverly system. The Cleveland shale is overlain by the Bedford shale which ranges between ten and sixty feet in thickness and which is sometimes red but oftener blue in color. Fossils are quite rare in it as a rule, but they are sometimes found and they agree with those of the Cleveland shale in belonging to Sub-carboniferous forms.

The Bedford shale is followed by the *Berea grit*, a well known tratum in northern Ohio, of great economic value and so largely 'orked as to be easily followed. It ranges in thickness from ten ɔ ninety feet and is everywhere poor in fossils.

The Berea grit is in turn covered by the *Cuyahoga shale* of Iewberry, a mass of blue shale interstratified with sandstone beds, anging from 150 to 250 feet in thickness according to Newberry nd extending from the Berea grit to the Carboniferous conglomrate. The Cuyahoga shale abounds in fossils which have long een known and studied and in regard to which no question exists. 'he lower portion of this stratum was described by Newberry as ark blue or sometimes black in color and heavily charged with ɔssils, among which a characteristic species of *Lingula* and also of *Ɔiscina* are reported.

This constitutes the Waverly group of northern Ohio according ɔ the classification of Dr. Newberry in 1870.

The Waverly group of southern Ohio, from the black shale up-'ards, is found to consist of the following elements. A mass of lue shale, often marked with red bands, from ten to ninety feet in hickness, directly overlies the black shale. It was recognized nd described in the State Geological Reports as the *Waverly shale*, he *Waverly blue shale* and the *Lower Waverly shale*. Immediately bove it is found the stratum of quarry stone, from which the 'hole formation derived its name, the thickness of which is between ve and fifty feet.

The quarry stone is in turn covered by a very persistent and ;ell characterized bed in central and southern Ohio, which was rst recognized and described by the late Professor E. B. Andrews, nder the name of the *Waverly black shale*. It is from fifteen to hirty feet in thickness, is highly charged with bituminous matters nd is extremely rich in fish remains, for considerable portions of ts extent.

Above the Waverly black shale comes a great mass of blue and andy shales, interstratified with beds of sandstone, the whole being :om 250 to 350 feet in thickness. Some valuable quarry courses ccur in this series, especially in its lower portions. In particular, ıe great quarries of the Ohio valley at Buena Vista and Rockville, 'om which Cincinnati and the cities of the whole valley have drawn › largely, are found to directly overlie this black shale that I have ıst named.

A heavy stratum of sandstone which in central Ohio becomes a coarse conglomerate completes the series here. This conglomerate was long a puzzling element. It simulated the true Carboniferous conglomerate perfectly and was mistaken for this stratum by the earlier geologists, but it was assigned to its proper place in the scale by Professor Andrews who showed it to be Sub-carboniferous in age. It is sometimes overlain by the fossiliferous shale and sandstone, to which the same author gave the name of the Logan sandstone, and sometimes by the Maxville limestone which has been proved to be of Chester age.

These are the series of the northern and southern portions of the state respectively, and they seem at first sight to be quite discordant, but their upper and lower limits are the same and a general equivalence must exist. Are there any continuous elements? Can any clew be found to lead out of the confusion?

A false clew was at first adopted and a misleading analogy was followed, to the great disadvantage of our geology.

It will be observed that a comparatively thin bed of black shale occurs in northern Ohio, overlain and underlain by blue shales, viz., the Cleveland shale, overlain by the Bedford and underlain by the Erie shale. A bed of black shale with similar boundaries has been noted in southern Ohio, viz., the Waverly black shale of Andrews. This latter stratum was assumed to be the true equivalent and extension of the Cleveland shale, and its fossils soon came to be credited to the latter. This identification placed the Berea grit of the north and the Buena Vista quarries of the Ohio valley on the same horizon. It also made the Cuyahoga shale the equivalent of the upper Waverly shales, the Waverly conglomerate and the Logan sandstone of southern Ohio. One unfortunate consequence of this identification was obvious. If the Waverly group begins with the Cleveland shale and if the Cleveland shale is the equivalent of the Waverly black shale, we find that the Waverly quarry stone—from which the whole formation took its name—drops out entirely from the Waverly series, and that this important stratum as well as the blue shale that underlies it, must be placed in the Erie shale.

The order is a false one, and it brought confusion into all parts of the series. Students of our scale came to believe that the equivalence of the different portions of the system constituted an unsolved if not an insoluble problem.

Out of this confusion and uncertainty, the Berea grit has helped

› lead us. When firmly held in its stratigraphical extension and ›uly followed, it proves to be a safe and reliable guide. It bridges ıe chasm that had been left in our series and stretches in un-roken continuity from the shores of Lake Erie to the valley of ıe Ohio. It makes a foundation on which the Sub-carboniferous ystem of the state can be securely built, and it offers the means ? correlation for the rocks of our scale, on the one side with ıose of Pennsylvania and on the other with those of Kentucky, hich have already been fruitful in good results.

More than this, if the history which its lithology and structure ›ntain is rightly interpreted, we find in it a very suggestive guide › much of the subsequent geological history of the state.

The Berea grit of northern Ohio is, as its name implies, a sand-one stratum, the first one to be reached in ascending the geologi-ıl scale of the state. In its best phases, it constitutes a building one of the highest excellence. Of the quarries that are worked . it at Berea, Amherst, Independence and other points, the an-ıal output already exceeds $1,100,000, according to the carefully ıthered statistics of the census of 1880.

The stratum varies considerably in grain, but it is never coarse ıd only in rare instances does it contain any pebbles. Its boun-ıries have a picturesque distinctness, the stratum on which it ›sts being red, and that which covers it being black or dark gray, ıe latter being also charged with characteristic fossils. There ıght to be no difficulty in following such a stratum across Ohio ıd there *is* none.

Professor N. H. Winchell first traced it to central Ohio, but to ıis part of the state, the Waverly quarry stone had been followed om the southward. To abandon the preconceived error, and to ›cept the now obvious conclusion that these two strata were one, ›st time and trouble, but when at last the truth was recognized, reconciled the facts that had before seemed so discordant and ›ought the first real harmony into the lower Waverly group of hio. The Waverly black shale of southern Ohio proves to be ıe black base of the Cuyahoga shale of northern Ohio instead of ıe Cleveland shale to which it was at first referred. The Waverly ›ue shale of southern Ohio is the Bedford shale of the north, like also carrying enough peroxide of iron to redden it in many in-ances.

But what of the Cleveland and Erie shales below? The latter a formation of extraordinary interest and economic value else-

where. The Venango and Bradford oil sands of western Pennsylvania lie buried within it or its eastern equivalent. What is its place in central and southern Ohio? Dr. Newberry was the first to show its fate. It wedges out upon the western shore of the sea in which it was formed and disappears. In volume II, Geology of Ohio, Dr. Newberry called repeated attention to the fact that in following the Erie shale westward from Cleveland, it thins rapidly and finally disappears, letting the Cleveland (black) shale directly down upon the "Huron" (black) shale, but the full significance of this fact and certain obvious conclusions from it escaped attention for a time.

The great belt of black shale that extends across the state is not the Huron shale of Newberry's classification, but a blended product of three epochs, otherwheres distinct, viz., the Cleveland, Erie and Huron. All of the facts match to this interpretation.

It was unfortunate that the type section of the group should have been measured where the section is shortest and where it contains the fewest elements.

A marked change in the geography of Ohio took place during the Bedford and Berea epochs. The western half of the state was mainly converted into dry land by the great extension of the Cincinnati axis, and both of the formations named above are shore deposits. They carry the proofs of their origin in unmistakable characters. They are ripple-marked from one end of the state to the other, and mud casts and worm burrows abound, especially in the Bedford shale.

The boundary of the Berea grit marks the margin of that ancient sea in which and around which, as it was slowly contracted, the mineral wealth of the state was chiefly accumulated. From this area the sea was gradually expelled by the deposition of sediments washed from the adjacent lands, but especially by the slow and steady rise of its immediate boundaries. The Cincinnati axis extends from north of east to south of west. The dip of the deposits formed within this sea, so far as it depends on the rise of the land, would be at right angles to the axis; or, in other words, to the south of east, in central and southern Ohio, and, as is well known, this is the uniform direction. The same gradual rise of land to the northward will explain the southerly dip of the same formations in northeastern Ohio and the adjacent parts of Pennsylvania.

But it is this contracted and aborted section, formed upon the

shallowing margin of this rising land, to which we have been referring all portions of the series with such confusing and unsatisfactory results. The Cuyahoga shale of Newberry, for instance, if made to include the interval between the Berea grit and the Carboniferous conglomerate, is certainly nowhere else, in all the circle of its occurrence, a mere shale formation. There is everywhere else, at any rate, a sandstone or conglomerate formation, near the summit of the series. It is the sandstone stratum of the Logan sandstone and the Waverly conglomerate of southern Ohio, and the Shenango sandstone of western Pennsylvania and northeastern Ohio. The normal section must be taken within the coast line named. It will include more elements and will have a thickness proportioned somewhat to its removal from this shore.

It is now possible to arrange the several strata that compose the original Waverly group of Ohio, in an harmonious and self-consistent order. Its elements are as follows, named in ascending order:

Bedford Shale ; Berea Grit ; Berea Shale = Waverly Black Shale ; Cuyahoga Shale, shortened so as to give place to the Logan Group, including the Waverly conglomerate, etc. ; Maxville Limestone.

All of these formations except the last can be traced with perfect distinctness across the state — most indeed can be followed in unbroken continuity — and now that the true arrangement is deciphered, it is so obvious and natural that we wonder that it should so long have been missed.

A single word as to the equivalences of the Waverly group in adjacent states. The Second Geological Survey of Pennsylvania is unravelling, thread by thread, the complicated history of the northwestern portion of that state. As in Ohio, the Berea grit takes a prominent place in the new adjustment. It becomes the Pithole grit of the Venango district, or the Third mountain sand. It is underlain by the red Bedford, and overlain by the Cuyahoga shale, which has been reported under various names as Crawford shales, Orangeville shales, Shenango shales.

One qualification, I wish to suggest. The Berea shale, as will be remembered, makes the roof of the Berea grit and the floor of the Buena Vista quarry stone. The former is a sandstone, the latter a freestone. The former is ripple marked and cross-bedded, the latter was formed in deeper water and is everywhere distinguished by remarkably even sedimentation. From this latter horizon, come in great part the natural flaggings of the state. In

Trumbull county of northeastern Ohio, the Berea shale grows very thin and thus the upper quarry courses come down close upon the Berea grit. I am disposed to believe that the Pithole grit of Pennsylvania, as reported in many borings of the region, consists of this joint product of the two systems. The Logan group of my scale certainly has its extension in the Shenango sandstone of western Pennsylvania and the beds that separate the latter from the Sharon conglomerate.

The section can also be followed into Kentucky, though there is doubtless a rapidly developing change in the series to the south of the Ohio river. Beyond this boundary, I will not trace it, but I will give the facts as they occur at Buena Vista on the north side of the river.

The Bedford shale is still distinguishable with normal thickness, but carrying a larger relative proportion of stone than to the northward. The Berea grit is clearly recognizable in the so-called "cliff stone" which has been quite largely worked here. The Berea shale (Waverly black shale) is a constant guide to the true order. The Buena Vista stone makes, as elsewhere, the base of the Cuyahoga shale, which is charged with more frequent freestone beds than to the northward. The Logan group makes the great ledge that overhangs the river in the vicinity of Portsmouth, dipping to water level near Catlettsburg. It is the "Knobstone" of Owen and the early geologists of Kentucky, and is overlain by the beds of the Sub-carboniferous limestone, rapidly thickening to the southward.

A single word as to the lower limit of the Waverly group.

I submit that this boundary ought to remain undisturbed where it has been fixed by unbroken use in the section of the state where the name originated, viz., at the base of the Bedford shale. Any other base, it is impracticable to establish.

Take the Cleveland shale, for example. This stratum makes the summit of the great black shale as shown across the entire breadth of Ohio, but its base, no man knows. Its fossils at the best are obscure and rare. Practically we cannot afford to throw away a firm and well maintained stratigraphical base for so uncertain and indefinite a boundary as the base of the Cleveland shale would be.

A CONTRIBUTION TO CROLL'S THEORY OF SECULAR CLIMATAL CHANGES. By W. J. McGEE, of Farley, Iowa.

[ABSTRACT.[1]]

BRIEFLY stated, Dr. Croll's theory of secular changes in terrestrial climate indicates that during periods of high eccentricity in the earth's orbit the hemisphere whose winters occur in aphelion suffers, through the intervention of physical and meteorological agencies, a diminution of temperature; while on the opposite hemisphere the temperature is correspondingly augmented. The object of the present communication is to direct attention to certain meteorological vicissitudes tending to produce such an effect, which appear to have been heretofore overlooked.

All extensive series of meteorological observations indicate the existence of a general law which may be expressed by the proposition: *Any increase in annual or diurnal thermometrical range is accompanied by a diminution in mean temperature.* An empirical coëfficient indicating the numerical efficiency of the law may be established by comparison of temperatures along meridians passing over sea and land. The mean temperatures under the twentieth meridian west, and the one hundred and twentieth meridian east from Greenwich, with the annual thermometrical ranges, are as follow:—

	LONG. 20° W.		LONG. 120° E.	
	January.	July.	January.	July.
	68.4°	73.3°	53.4°	78.8°
Annual means,	70.8°		66.1°	
" ranges,	4.9°		25.4°	

From these figures it appears that the mean temperature is 4.7° lower, and the thermometrical range 20.5° greater, over the land-meridian than over the water-meridian; which ratio yields a coëfficient of diminution (which may for the present be assumed to remain constant) of 0.23° for each degree of increase of range.

When the solstices are at right angles to the apsides, equal amounts of solar light and heat are received by both hemispheres during corresponding seasons. The amount so received may be denominated the *normal accession*. When, however, the solstices coincide with the apsides, that hemisphere whose winters occur in aphelion receives a less than normal amount of light and heat in

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winter, and a greater than normal amount in summer, owing to the variation in solar distance at these seasons. If, then, terrestrial temperature is a function of solar accession, the annual thermometrical range on the hemisphere so situated must be greater than the normal; while on the opposite hemisphere the range must be diminished. Moreover, any increase in the eccentricity of the terrestrial orbit must intensify this effect, since solar accession varies as the square of the solar distance. Computing the actual accession when the hemispheres are in the former position, and reducing the same to degrees Fahrenheit by means of a coëfficient (also assumed to remain constant), it appears that the increase in annual thermometrical range beyond normal is 21.0° with the present eccentricity (0.0168), and would be 93.7° with an eccentricity of 0.0747. Making use of the coëfficient already determined (0.23°), it is found that these values are equivalent to a diminution in mean temperature, over the hemisphere whose winters occur in aphelion, of 4.83° and 21.55° respectively, and to a like increase in the temperature of the opposite hemisphere. These values are, however, probably excessive—the error arising from the use of constants where the factors are actually variable—and should be diminished in the ratio of 212 : 80; yielding 1.82° and 8.13°, respectively, as tolerably trustworthy values for the diminution of mean temperature effected by the operation of the law stated at the outset.

Applying the first of these values to the earth in its present status, it would appear that the temperature of the southern hemisphere ought to be about 3.5° lower than that of the northern. The approximate coincidence between this result and those derived from observation strengthens the conviction that the principles detailed must be valid. Applying then the second value to the earth when the eccentricity is near its superior limit, it appears that the hemispheres should vary in mean temperature by no less than 16°—that secular summer should prevail in one, while the other was enshrouded in the snows of its secular winter. The importance of the agencies described will perhaps be more manifest when it is borne in mind that during its secular summer more solar heat and light are received by a hemisphere in winter than in summer, while on the opposite hemisphere the solar accession is no less than $1\frac{1}{5}$ times greater in summer than in winter.

THE GOLD-BEARING DRIFT OF INDIANA. By GEORGE SUTTON, of Aurora, Indiana.

[ABSTRACT.]

NEAR the northeast corner of Indiana may be seen accumula-lons of drift that have been brought along converging lines from listant and widely separated portions of the country. We may ee that which came down the Ohio river from the northeast, that rhich was brought down the Miami from the north, that which ame down the White Water from the north-northwest, and that rhich passed down the valley of Laughery from the west and orthwest. In addition to stratified valley drift there are glacial eposits upon the most elevated portion of country above the hio river, as seen in Boone county, Kentucky, where in some laces they cap the hills on each side of the streams, suggesting ie interesting question as to the extent of glacial deposits prior the formation of these valleys. We have also glacial deposits ithin the valleys presenting the evidence of valley glaciers with eir lateral and terminal moraines. These different deposits of ift may be seen within a few miles of each other near the rtheast corner of Indiana presenting a marked difference in lor and composition. While portions of this drift are largely mposed of material from the silurian formations, there are her deposits principally composed of crystalline rocks with large iartz and granite bowlders, magnetic iron ore in the form of ack sand, and gold in considerable quantity. It is to these eposits of gold-bearing drift which are not only found in south-astern Indiana, but also in other parts of the state that I wish to irect attention. They present the most conclusive evidence of a lacial action, and northern origin.

It is well known that gold in minute quantities is a very widely isseminated metal, and is found in the drift in different portions f Indiana, also in several localities in Ohio, but it is not equally iffused throughout the drift formation. The irregular manner in rhich it is deposited presents facts from which we shall endeavor to how that there is a line of drift, bearing gold, extending across the tate from southeastern Indiana in a west and northwest direction o Illinois, and that the drift along this line is comparatively rich 1 gold, while the gold that is found in other parts of the state is 1 such small quantities that it is with difficulty detected.

Along the valley of Laughery creek, a stream which enters the Ohio river a few miles below the mouth of the Miami, may be seen deposits of this auriferous drift. They are not stratified like the terrace formations seen along our rivers, but lie in irregular accumulations along the valley. At the bottom of the small streams that have cut across this drift are seen deposits of black sand already alluded to which principally consist of magnetic iron ore. It is in this sand that gold is found. Seven miles from the mouth of Laughery may be seen a deposit of this drift about a mile and half in length, nearly half a mile in width, and about one hundre feet in thickness. From the absence of stratification, the irregular manner in which it is deposited in the valley, and the larg number of quartz and granite bowlders lying upon its surface some of which would weigh several tons—this drift, we thin presents the most conclusive evidence of glacial action, and being the terminal moraine of an ancient valley glacier. It is regarded by Prof. Cox in the geological report of Indiana for 1878 in which it is briefly noticed. This glacier *must*, however, ha moved down the valley of Laughery, coming to this point n directly from the north, but from the west, as a glance at t map of Indiana will show that Laughery runs east and west for considerable portion of its course. This deposit in Laughery va ley differs widely in composition from the drift deposits seen alo the valley of White Water or the Miami, or those in Boone count Kentucky. The extensive deposits in Boone county, although i sight of the drift in Laughery valley, are principally composed silurian formations, with a small per cent. of crystalline rocks an an occasional quartz and granite bowlder. No gold nor magnet iron ore has been discovered in this drift, while there is scarcel any difficulty in finding gold in the drift of Laughery valle Some portions of the Laughery drift are so rich in gold that it seen with the unaided eye, and almost pays a fair remuneratio washing for it. My attention was directed a few weeks since, b the owner of the farm on which this drift is found, to a small excavation which had been made in washing for gold. It was b measurement six feet long, five feet broad and about two fe deep. He informed me that from this place eight dollars wor of gold had been obtained, and that a man had washed from t drift on his farm gold to the value of sixteen dollars and fift cents. The gold is found in the form of dust, flattened scale

and small nuggets. Only that which could be seen with the unaided eye was saved.

Now as this gold-bearing drift with its crystalline rocks is foreign to our state, we naturally inquire over what portion of country did it pass to reach the southeastern corner of Indiana. There is no evidence that this drift came directly from the north, for it is not seen upon the highlands on each side of Laughery valley, nor upon the tablelands until we reach Ripley county at the headwaters of Laughery creek. We trace it, however, along this valley towards the west, and find upon the highlands and flats of Ripley county the most conclusive evidence of glacial action. We are told in the geological reports of Indiana that the "evidences of glaciation are seen over the entire county [Ripley] and doubtless the paleozoic rocks will be found marked by the abrading forces then at work." We are also told that "black sand is found in this county which readily adheres to the magnet when dry." Although the evidence is not recognized in our geological reports that the auriferous drift found in southeastern Indiana was brought across the state from the northwest, still the facts presented in these reports will be the principal evidence that we shall bring forward to show the deposits of gold-bearing drift, and to trace the line along which glaciers moved.

Passing west from Ripley county to the adjoining county Jennings, we see again the effects of glaciation. We are told in the geological report of this county that "bowlders of stratified rocks are sometimes found, while granite bowlders of various sizes are met with throughout the county, in many places quite large and abundant. They occur quite frequently in the region bordering the south fork of the Muscatatuck. The largest bowlder seen in the county is found here, and measures eight feet in length, five feet in width, and the same in thickness. It is a very dark, hard granite." It is also stated (p. 121, of the same report) "that small particles of very pure gold are frequently found in the sands." We are also told "that particles of gold had been panned from the bed of the south fork of the Muscatatuck. This gold was found in combination with black sand washed down from the glacial drift of the uplands." We are also informed "that the excitement occasioned by this discovery was very great at the time and some useless labor was spent in sinking a shaft, as the drift and accompanying gold dust were foreign to the state."

In the Annual of Scientific Discovery for 1851, p. 292, is a notice taken from a communication of Prof. T. A. Wylie of the Indiana University, that gold was found in Morgan, Jackson, Brown and Green counties, comprising a district of "about forty miles in length by twenty-four in breadth." It is then stated that this gold is always associated with black sand. Jackson county joins Jennings on the west, and bears the most conclusive evidence of glaciation. In the last geological report of this county we are told "that the influences which the glacial period has had in modifying the topography of this county are remarkable and at the same time difficult to explain in a satisfactory manner." Joining Jackson county on the north and northwest is Brown county. In this county gold is found in comparatively large quantities, and the evidence of glacial action is as remarkable as can be found in any part of the state. We are told by Prof. Collett in the geological report of Indiana for 1874 "that gold is found in the bed or on the bars of *all* the brooks that flow into Bean Blossom from India Creek ridge, and on the streams which flow from the foot of the drift backbone in the northeast corner of the county as south Bean Blossom, North Salt Creek, etc. Fine dust and minute scales may be found farther within the county wherever black sand and small pebbles indicate former currents of ice-water even as far south as Elkinsville." He says "the gold is of unusual purity averaging nearly twenty-four carats fine." "Single individuals at favorable points, by hard, patient labor, have been able to make from one to one dollar and a half per day. Companies and careless workers have not averaged more than twenty-five cents per day. During the excitement a few years since several companies took leases, made sluice-ways and prepared rockers. The returns were not satisfactory. It is probable that the best 'pay dirt' lies at the deepest part of the rocky trough in which the creeks now have their course. By bores the line of greatest depth may be ascertained, and by shafting the richest 'dirt'—possibly in paying quantities — may be brought to the surface. Reasoning from the facts observed this would be true of Bean Blossom, and especially from its greater width and probable great depth also of Indian Creek valley. This is mentioned as a reasonable deduction warranted by the facts." We are also told in the geological report of this county that up to 1874, "gold had been taken from Salt Creek to the value of one thousand dollars—near Georgetown, five hun-

dred dollars; near Anderson, three hundred dollars; at Richards farm and adjoining, four hundred dollars; at Plum Creek, sixty dollars. It was then published in the report that altogether upwards of 10,000 dollars worth of gold had been procured. But gold has been taken from this drift that was not accounted for. I have been credibly informed that it was a custom with farmers, even in Ohio county, after the harvest was gathered, to take their tents to the drift along the Muscatatuck or to that in Brown county, camp in the woods and wash for gold, and in many instances fair wages were made.

I think that we can safely say that upwards of 12,000 dollars worth of gold has been obtained from the drift of Brown and Jennings counties; some of the nuggets weighed were of the value of one dollar and ten cents.

Adjoining Brown county on the north is Morgan county. We have already mentioned that it is stated in the Annual of Scientific Discovery that gold has been found in this county associated with black sand. Prof. E. T. Cox informs us in the geological report for 1878, page 116, that the most noted places in Indiana where gold is found in glacial drift are in Morgan and Brown counties. Passing in a northwesterly direction to Montgomery, the adjoining county, we find in the Geological Report for 1875, page 370, that "the bowlder drift covers the eastern, northern and northwestern parts of the county bearing internal evidence of its origin such as polished and rounded pebbles and rocks imported from the Laurentian beds of Lake Superior. When long concentrated by currents of water some notable deposits of gold-dust and magnetite occur." Here we find gold again associated with magnetic iron ore.

To the northwest of Montgomery and also joining this county is Warren county. Professor Collett tells us in his interesting report of this county, "that small nuggets of galena, virgin copper and gold are found which were imported from the north with the rocks of the bowlder drift." "At Gold Branch of Pine Creek in this county, on a gravel bar formed of the débris washed from the bowlder drift, a quantity of gold reported at seventy dollars was collected, and we are told that an energetic Californian can pan out from one to one dollar and twenty-five cents per day at this, and several other bars in the county."

We have now traced glacial action, and almost a continuous line

of gold-bearing drift associated with magnetic iron ore across the state from southeastern Indiana in a west and northwest direction through the counties of Dearborn, Ohio, Ripley, Jennings, Jackson, Brown, Morgan, Montgomery and Warren to Illinois. In some places along this line the drift is comparatively rich in gold. No other portion of the state presents gold in such quantities, although drift is distributed all over the northern part of the state. In a large portion of this drift no gold is found, and in those places where it is found to the north or south of this line it is in such minute quantities that it is scarcely discernible.

After tracing this auriferous drift across the state almost in a continuous line from the southeast to the northwest, the questions naturally arise, are these gold deposits merely coincidences along this line in the drift formation, or was there an ancient glacier more richly ladened than other glaciers which, in moving across the state from the northwest, left its trail in a line of gold by which we can now see the direction whence it came? We know that at the present time the general drainage of the state is towards the southwest, yet the glacier has left its record upon the rocks showing by its striæ that at one time its movement was towards the southeast. In the geological report of Montgomery county we are told "that the glacier was deflected to the east by the highlands seven or eight miles north of Crawfordsville near Mt. Pleasant Chapel passing between this point and Romney, thence southeast by Darlington towards Fredericsburgh leaving a trail or dyke of immense bowlders along its track filling up some of the depressions and floating over others." At two localities, we are told, "direct positive evidence of the ice-flow recorded by the glacier itself was observed," "well-marked striæ in a right line indicate the direction south eight degrees east." At another place the striæ pointed "south eighteen degrees east with an apparently greater *easting* at other localities. In Owen county which is near the line of this gold-bearing drift as it joins Morgan and Monroe counties, Prof. Collett tells us "glacial striæ cut in the conglomerate were seen in the southeast quarter, section twenty, township nine, range five, the striæ having a confused direction of south eighteen degrees east to south forty-six degrees east." We see that in Clay county which joins Morgan on the west that over this portion of the state glaciers also moved towards the southeast. The course of the marks taken with a surveyor's compass is

as follows: "well-defined striæ point south 26° 31′ east, smaller ones south 30° 35′ east, on the southeast quarter of the northwest quarter of the same section they point south 29° 30′ east. At another place the striæ were very distinct, and pointed south 26° 30′ east." "On the east half of section one, township eleven, range six, are four exposures at one station; combined they show an area of about thirty by one hundred feet, planed to a level almost as smooth as if the work of man. The hard ferruginous sand-rock retains the striæ in perfect preservation fully as well as at the famous exposures on Kelley's and Put In Bay islands so highly appreciated, and so often visited by geologists. The course is south 26° 20′ east." (See geological report for Indiana, 1875.)

We see then from our geological reports that we have positive evidence that glaciers did move obliquely from Warren county toward the southeast at an angle of from 30° to 46° east of south, a direction which would be towards the southeastern portion of the state. We know that in passing down the valley of Laughery the glacier *must* have moved towards the east before it formed its terminal moraine seven miles from the Ohio river, as this stream runs east and west. If the line that we have traced obliquely across the state is not the trail of glaciers that left one of their terminal moraines in Laughery valley, how came such conclusive evidence of glacial action along this line as seen in the striæ pointing to the southeast, the striæ associated with trails of drift, with quartz and granite bowlders, and other crystalline rocks brought from the north? and why do we find gold and magnetic iron ore along this line in so much greater quantity than can be found in other portions of the state, as this gold and magnetite we know are of northern origin? From these facts it appears to me that we have conclusive evidence that the auriferous drift, seen in southeastern Indiana, was brought by glacial action obliquely across the state from the northwest.

It is almost certain that during the long glacial period the ice did not always move in one uniform direction over the comparatively level surface of our state; but, meeting with obstructions, accumulations at certain points took place and glacial streams were deflected to the east or west, leaving lines of drift pointing towards different directions. These lines have been crossed by streams of *later date* presenting confused accumulations of drift deposits, making it so difficult in some places to unravel the phenomena presented by the drift period. We have said that gold is found in

other portions of the state. From an examination of our geological reports, and from all the information that I have been able to obtain, I find that gold has been found in very minute quantities in Vanderburg county, in Gibson county, which is the adjoining county directly north, and also in Pike county which joins Gibson on the northeast. It has also been found in Sullivan and Franklin counties in small quantities. We find drift all over the northern portion of the state, but gold has only been found in certain localities and in certain deposits of this drift, and not equally diffused throughout our drift formation. Thus we see that there were glacial streams loaded with quartz and granite bowlders, crystalline rocks containing magnetic iron ore and gold, and there were other glacial streams producing deposits in which neither magnetic iron ore nor gold is found.

I have seen notices that gold has also been found in the state of Ohio in local deposits. It has been found in Geauga county, in Warren, in Clermont the adjoining county to the north, also in Licking and Knox counties (Knox joins Licking on the north). From these facts it appears that both in Indiana and Ohio gold is found in certain local deposits.

There were also glacial streams in Ohio that moved from the northwest. We are told in the geological survey of Ohio, Vol. I, page 420, in the report of Hamilton county: "These facts seem to point to glacial erosion as a prominent cause in the production of the surface feature of the country as the glaciers are known by the *striæ they have left to have advanced from the northwest.*" Also in the report of Clark county, page 456, we find the following statement: "The striæ in Clark county bears a *general direction of south* 12° *east.* There is besides this abundant evidence of a general southeasterly trend in the transportation of local deposits, which can be traced to their sources."

We have traced this gold-bearing drift in a line across the state of Indiana towards the northwest. In some localities, as we have seen, considerable amounts of gold have been obtained from comparatively small deposits of drift, and along this line gold to the value of thousands of dollars has already been procured, and along this line there must be gold of immense value yet undiscovered. Are not these facts as indicative of rich veins of gold somewhere on the northern portion of the continent, as the nuggets of copper and galena found in the drift were of the rich copper mines of Lake Superior, or lead mines of Iowa and Wisconsin? The evidence of

;old in the drift appears to me to be even more conclusive of rich 'eins of gold in the north, than the evidence of copper or lead in he drift is of the lead or copper mines with which we are now 'amiliar. We know that in our geological reports but little imporance is attached to these deposits of gold; but when we take into onsideration the northern origin of this gold-bearing drift, the reat distance it has been transported, its richness in certain loalities in gold, the large amount of gold found in comparatively nall deposits of drift, the size of the nuggets, their remarkble purity, and that this gold is always associated with magnetic on ore, are not these facts important? Are they not worthy of areful consideration as indicating the probable future discovery f rich gold fields in the north?

The discovery of gold in rich veins or rich deposits is always n important event in the history of a country, and every fact, o matter how insignificant at first, is afterwards regarded as imortant in directing attention to the discovery. The fragments f gold found in the valley of the Sacramento in 1848 were, we hink, not more indicative of rich gold mines, which have since een discovered in the Sierra Nevada, than that the gold found in ndiana points to future discoveries of rich gold-bearing rocks somerhere in the northern portion of the continent. It is probable hat the gold veins are not extensive, or they would have been iscovered, and rich deposits of gold would have been more genrally diffused throughout the drift formation. Gold veins may e rich in small circumscribed localities. We read that at Ballaat, in Australia, the rich veins of gold occupy less than a square nile in extent, and that within this small space seven thousand niners were employed. There is a vast extent of country on the iorthern portion of our continent from which glaciers moved, and large extent of country which has never yet been carefully examined, and I think we are not visionary in saying that we beieve it is probable that rich gold veins may yet be discovered eyond the lakes, which will give rise to all the excitement incilent to the discovery of new gold fields, and the miner, the capialist, the speculator, the emigrant and the adventurer, may hurry o a region of country which is now but a barren wilderness, and illages, cities, and railroads may rapidly come into existence, nd scenes be enacted in the north similar to what we have so ecently witnessed in the west.

The Recurrence of Faunas in the Devonian Rocks of New York. By H. S. Williams, of Ithaca, N. Y.

The general similarity in the lithological characters of the Marcellus shale and the Genesee slate of the Devonian age, and of these to the Utica slate of the Silurian was early noticed in the Reports of the Geological Survey of New York.

In the Report on the fourth District (1843) Professor Hall called attention to the occurrence in the Genesee slate of three species, also observed in the Marcellus shale.

The recent discovery of these same three species, with others in a still higher zone led the writer to make a careful study and comparison of the faunas of the three zones, resulting in the discovery of a remarkable similarity in the total faunas of each of the three zones.

Ten species were found common to the three zones, six species common to two of the three, and three genera with representative species in each zone. Although defined as distinct species in each case, these three species are clearly only slight modifications of the same type thus appearing in each zone.

The zones, as represented in central New York state are the black, or dark shales of

(1) The Marcellus shale,
(2) The Genesee slate, and
(3) The Ithaca shale.

Interposed between these zones of shale are the following well-marked formations; viz.:

Between 1 and 2, (*a*) the *Hamilton* with its rich and varied fauna, (*b*) the thin *Encrinal limestone* with a distinct, if not abundant fauna, (*c*) the *Moscow shale* with a fauna closely resembling the Hamilton, but distinct in many species, and finally the widely extended (*d*) *Tully limestone* with characteristic fauna and very marked lithological features.

Between the 2nd and 3rd zones are the nearly barren *Portage* shales and limestones, clearly distinguished from the lower strata lithologically, and with a fauna very distinct, in the few fossils which do occur, from the faunas above and below.

We notice, further, that the arenaceous character of all this series, from the Marcellus to the Chemung, is stronger in the eastern, than in the western part of the state.

In the Portage rocks this difference is conspicuous in passing :om the western limits to the central part of the state. In the ›rmer localities the rocks are mainly argillaceous shales, while in ıe latter the arenaceous layers predominate and are characteristic ' the formation, though not so marked as in the higher Chemung ›cks.

The name *Ithaca Shale* is proposed for a soft, fragile, argil- ceous shale, very similar to the lighter colored masses of the arcellus shale, and found well represented at Ithaca, N. Y., form- g transition beds between the Portage and Chemung rocks. The ant beds, in which *Lycopodites* (*Ptilophyton*) *Vanuxemi* is abund- t and beautifully preserved, are within this Ithaca shale.

This shale is often stained reddish by decomposition of iron rites, but upon being freshly removed, before exposure to the ather is a soft argillaceous shale closely resembling portions the Marcellus shale.

Where it occurs in Ithaca and neighborhood it is well character- ed by the presence within its mass of the peculiar formations lled "channel-fillings" (in a paper by the author in American urnal of Science, XXI, April, 1881, page 318). These are rrow beds of nearly pure sandstone, whose section is deeply nvex below and nearly flat above, lying in the midst of the ft shales. They appear to be of pretty uniform character roughout; the longitudinal axis of those observed lies in a rection about twenty degrees east of north, and their average ze is six to eight feet wide and nine to twelve inches thick the centre.

Lingula complanata is the most characteristic fossil of this ıale, and in some of the strata is abundant.

The total thickness is about twenty-five feet, the lower boundary ›t clearly defined, but where *Spirifer lævis* has been found in the ›rtage below, the top of this shale is observed to lie fifty to xty feet above the highest strata containing that fossil.

The species recorded from each of the three zones are *Lunulacar- um fragilis*, *Chonetes setigera*, *Chonetes lepida*, *Styliola fissurella*, *entaculites gracillistriatus*, *Leiorhynchus limitaris*, *Orthoceras bulatum*, *Goniatites* (*Clymenea*) *complanatus*, *Cardiola speciosa*, *oleolus aciculum* (including the variety called *C. tenuicinctum*).

Common to two of the three zones are found in the second and ird, *Leiorhynchus quadracostatus* and *L. mesacostalis*; these may

be only varieties, but an imperfect specimen of the *qradracostatus* type has also been taken from the first zone.

In the first and third zones are found *Ambocœlia umbonata*, *Productella shumardiana* and *P. truncata* and an unidentified species of *Leptodesma*.

The genera represented by species in each zone are

Lingula—with *L. manni* (central Ohio) in the first, *L. spatulata* in the second and probably in the third, *L. complanata* in the third;

Discina—with *D. minuta* in the first (see also *D. humilis* and *D. media* in the first), *D. lodensis* in the second, *D.* (?) *newberryi* in the third.

Leiorhynchus—with *L. limitaris* in the first abundantly, and rarely seen in the second and third, *L. quadracostatus*, a single imperfect specimen in the first, characteristic of the second and not uncommon in the third, *L. mesacostalis* as a variety in the second and third, and regarded as characteristic of the later Chemung epoch.

The name *Lingula complanata* is proposed for a new species in the Ithaca shale, which has been generally confused with *L. ligea* of Hall, but is distinguished from this species (as described and figured) by its uniform flatness and thinness and the sub-rectangular form; the sides are nearly straight and parallel, the base abruptly truncate and the cardinal margin only slightly arched.

The average size of this species is 12^{mm} long by 9^{mm} wide, which is larger than the average *L. ligea.*

The contour is very much like that of *L manni*, but the shell is proportionally shorter in *L. complanata* and more delicate and thin. Though readily distinguished morphologically from *L. manni*, it is a closely allied species.

The Discina, doubtfully referred to the species *D. newberryi* H., of the Waverly group of Ohio, is rare in the Ithaca shale. It is circular in form, about the size of *D. lodensis* of the Genesee slate, but with strong concentric striæ, or lamellæ like *D. humilis* or *D. newberryi*, and much like a magnified *D. minuta*, and in combination of characters strongly resembles *D. newberryi* though the apex is not so high nor so eccentric as ordinarily represented in the latter species.

In the upper part of the Ithaca shale a few species are met with, belonging to a Hamilton fauna, which begins to recur here, but is more distinctly represented in thin argillaceous layers lying be-

een the coarse arenaceous strata at the base of the following
emung epoch.

The following species have been identified in this recurring
amilton fauna:

Spirifer fimbriatus, *S. angustus*, *Ambocœlia umbonata*, *Loxoma* (?) *delphicola*, *Pleurotomaria capillaria*, *Modiomorpha contrica*, *Lingula punctata* and *Lingula spatulata*. There are a few er species, all of the Hamilton type, but not certainly identified th the species of that group.

It will be seen that all the species mentioned are characteristic amilton species, and most of them have been hitherto regarded as culiar to that period or to lower horizons.

We do not hesitate, then, to consider this as a recurrent Hamil- fauna, occurring at the base of the Chemung epoch, entirely ove the Portage, though, as far as at present known, before the aracteristic Chemung fauna has appeared in this central New rk locality.

An examination of the fauna of the Utica slate, although show- g no cases of identity of species with those of the Devonian ack slates, offers some interesting resemblance. The following amples may be mentioned:

Endoceras proteiforme of Utica slate, compare with *Orthoceras bulatum*. It is noticeable that the Utica slate *E. proteiforme* does t have the outer cone with its wide siphuncle, so characteristic of e Trenton forms, and upon which the genus is based; compare so, *Lingula rectilateralis* Con., or *L. quadrata* H. with *L. manni* d *L. complanata*; *Avicula insueta* with *Leptodesma* sp., of the arcellus and Ithaca shales; *Cleidophorus planulatus* Con. with *C. longus* of the Hamilton and *Trocholites ammonius* (the smoother d smaller forms) with *Goniatites* (*Clymenia*) *complanatus*.

Mention was made also of a possible relationship between the *ptœna sericea* and the genus *Chonetes* which is not abundant the Devonian, though sparingly represented during the in- val.

The flora associated with this recurrent fauna in the Ithaca les appears in only slight traces in the lower zones. The car- naceous nature of these lower shales, however, suggests the bability that plants were abundant but were comminuted or cerated by action of the elements, so that the individual forms the plants were not preserved.

Stems of *Rhodea* have been seen in both the Genesee slate and the Ithaca shale, though not in the lowest zone.

In the paper, as read before the Association, comparison was made of the several species, appearing in the separate zones, bringing out the fact that, of the forms which have been called distinct species in the separate zones, those of any one genus are uniformly of the same type and section of the genus and in each case are closely allied species, if not merely varieties of one identical species.

We have not space here to give these interesting details, but suffice to say that the variation seen in passing from the lowest to the highest zone is very slight, and in no case greater (except in size) than appears to be normal to the species in any particular zone of its occurrence.

The following are, briefly stated, some of the conclusions drawn from the study of these several faunas:

1. The same fauna, which was well defined in the Marcellus shales, recurs, with very slight modification, in the Genesee slate and the Ithaca shale of New York.

2. This recurrent fauna of New York state is the same fauna which characterizes the Black shales of Ohio, Indiana, Kentucky, Tennessee and other regions in the interior of the continent.

3. The fauna was a single continuous fauna, and, during the early and middle Devonian age, its centre was located to the southward and westward of New York.

4. Its appearance in the rocks of central New York in three separate zones, called the Marcellus shales, the Genesee slate and the Ithaca shales, is regarded as evidence of interrupted incursion eastward of the conditions which were continuous over some portions of the interior of the Devonian inter-continental sea where the three New York zones were represented by one continuous series of Black shales.

5. The hypothesis is also advanced that (*a*) the Hamilton and Chemung faunas were probably coexistent with this Black-shale fauna; and (*b*) were respectively the northern and southern faunas of a western coastline of the open ocean on the eastward of this continent; and (*c*) the appearance of the Chemung fauna, displacing the Hamilton faunas, in the latitude of New York and Pennsylvania, was the resultant of some grand changes in the relations of the ocean and continental borders, by which tropical

conditions of the ocean were advanced northward, occasioning the shifting of the Hamilton faunas toward the North pole; so that, (we may suppose) at the time when the Chemung fauna was dominant over the northeastern United States, rocks being deposited in the arctic latitudes received a Hamilton Fauna, and (*d*) finally, these changes were gradual, the shifting of the faunas northward beginning as early as the beginning of the Portage epoch and continuing far into, and perhaps after the close of, the Chemung epoch, with some oscillation of the conditions, causing traces of the Hamilton to recur at the base and, possibly a second time, higher up in the midst of Chemung rocks and faunas.

ON THE OCCURRENCE OF AN ARCHIMEDIFORM FENESTELLID IN THE UPPER SILURIAN ROCKS OF OHIO. By E. W. CLAYPOLE, of Yellow Springs, Ohio.

[ABSTRACT.]

THIS paper gave an account of the discovery at Cedarville near Yellow Springs, Ohio, of a large spiral form of Fenestellid differing from Archimedes in not possessing the stony axis characteristic of that genus. The polyzoary is widely expanded, sometimes measuring six to eight inches across, and very flat, the whorls not being more than half an inch from one another. It occurs in the upper part of the Niagara rocks, as there exposed, forming what is called in Canada the Guelph. The roughness of the stony matrix in which the specimens were found renders very indistinct some of the minute characters, but it is completely distinguished from all known forms of Fenestella by its strongly marked and constant spiral form. It appears therefore to form a connecting link between Fenestella and Archimedes and its structure renders it not improbable that the stony axis of the latter was gradually developed by the thickening of the inner edge of the spiral polyzoary.

Another species, not yet described, is known to exist of somewhat similar form from the Upper Helderberg rendering the above suggestion more probable. The species described in the paper was considered as the type of a new genus to include the spiral Fenestellids and named *Helicopora latispiralis*.

NOTE ON SOME FISH-REMAINS FROM THE UPPER DEVONIAN ROCKS IN NEW YORK STATE. By H. S. WILLIAMS, of Ithaca, N. Y.

[ABSTRACT.]

THE author described several small fish bones from the Devonian rocks at Ithaca, N. Y. The exact horizon is in the Chemung, near the base, and below in the Ithaca shales, which form the transition between Portage and Chemung.

The form and peculiar markings were the interesting features in the specimens.

One was elongate oval, much like the elytron of a beetle, the other, more produced and pointed at the end, which was incurved, the convex margin of each being thickened and the opposite side running out into a blade-like expansion, and covered by a reticulation of veins. The veining on the elytron-like form is made up of several strong, longitudinal, nearly parallel, linear veins connected by finer cross veins.

In the larger, pointed specimen (1¼ inches long), the veins proceed from the broad, convex, axial margin, run along toward the point nearly parallel, diverge, and terminate upon the free thin margin, the longer veins terminating upon the serrate points at the margin. The cross veins are irregular.

Both specimens are unsymmetrical, concave on one side, which appears to be the underside, and convex on the other veined surface. At first glance they appear like insectean, or crustacean remains, but closer examination of the larger specimen, of which some of the substance of the bone is preserved, reveals the structure of fish bone.

The occurrence in the same slab with one of the latter of a distinct fish jaw with teeth (another was found in the same bed), of the Ceratodus, or Dipterus type, has furnished suggestion as to their nature.

The jaw consists of a thin, oblong plate produced into a lobe-like expansion behind, the outer margin, gently curving and beset above by a single row of distinct teeth-like serrations, standing vertical upon the plate. There are five in the series, which curves with the outer margin of the plate; the longer is the more anterior, and they gradually diminish toward the posterior end. The whole jaw is about half an inch long, and the longest tooth is something

over a line in height. The edges facing each other are trenchant.

These teeth resemble *Dipterus sherwoodi* of the Catskill more nearly than any species I have seen described, although there appears to be but a single row of denticles, corresponding to the outer one in that species. I have therefore provisionally put it in this genus, under the name *Dipterus Ithacensis*.

A study of Ceratodus and allied fish makes it probable that no endoskeletal parts were ossified in these Devonian fish, and it is conjectured that the peculiar bones are probably the pectoral fin spines or covers of a fish with teeth (of a single row) like Dipterus, showing some relationship perhaps to Pterichthys.

The shorter elytron-like specimen is from the Chemung, three hundred feet above base, at Ithaca, associated with Mollusca. The larger pointed form is from Ithaca shales, at base of Chemung, associated with plant remains, a few frail Mollusca, and a large fish bone, probably a head plate of Dinichthys.

Remarks on the Classification and Distribution of Producti.

By S. H. Trowbridge, of Glasgow, Mo.

The work of which this paper gives a brief notice was begun some years ago with a view to determining the differences, if any, between European and American species of the genus Productus.

But the species of the same name, according to different authorities—or even to a single authority—were found to differ so widely that the question of geographical distribution, from *named specimens*, was involved in a maze of inextricable confusion. Before determining this point, therefore, it seemed necessary to decide what description of specimen should be considered as entitled to exclusive use of any given name. To determine this from recognized authorities was found to be almost equally confusing, from lack of harmony between the specimens and their descriptions and figures as given by even those who originally described them. Hence it became necessary to go farther back and inquire whether there is in existence a satisfactory classification of the Producti.

Having been compelled, from all accessible data, to answer this in the negative, the still more fundamental inquiry was forced upon me: *can* the species of Producti be satisfactorily classified? or must we conclude that the species so run into one another that the lines of distinction cannot be clearly made out, or must be drawn arbitrarily? The last two finally became the first and main questions to answer, and are so discussed here, the other questions mentioned receiving light only somewhat incidentally, but with sufficient clearness, it is hoped, to show good reasons for the conclusions reached.

In making comparisons concerning these forms I have had recourse to the descriptions and figures of both European and American authorities, giving especial attention to works containing original descriptions and figures, and, perhaps, to tons of specimens; including those from the Geological Surveys of Kentucky and Missouri, from years of private collecting in the Western states, and all those from every quarter of the globe, found in the fossil collections of the Museum of Comparative Zoology, many of which were the specimens originally described. To make the conclusions as satisfactory as possible, I have made separate comparisons respecting size, shape and general appearance, markings on the dorsal and ventral valves, spines, configuration of both valves, sinus, beaks, ears, hinge-line, etc., putting each in a separate column for more convenient reference, as will be seen by referring to tabulated descriptions, etc.[1]

The question of classification divides itself into two parts: 1, as to external peculiarities: 2, as to internal markings.

DeKoninck, in his text of Animal Fossils, bases a tabulated classification on: 1, presence or absence of longitudinal striæ and size; 2, continuity or bifurcation of striæ, and peculiarities of spines; 3, presence or absence of transverse plications; 4, of lobes. All authorities agree in basing classification, founded on the external view, on some or all of the following peculiarities, which will be noticed somewhat in detail, not however, in relation to all the so-called species of Productus, but, for the sake of brevity, to only what may be fairly considered representative species.

1. Size and shape. By studying carefully the tabulated data in the columns devoted to this point, the following facts, among

[1] The tables and drawings referred to in this paper were exhibited in the Section when the paper was read, but were not presented for publication.

many others, appear. In size, from verbal descriptions, the species are arranged, beginning with the largest, thus: costatus Sow., antiquatus, semireticulatus, martini, flemingii, var. burlingtonensis, longispinus DeK., spinosus, flemingii Sow., longispinus Sow., lobatus, and concinnus. From the figures the arrangement is somewhat different: semireticulatus Mart., martini Sow., costatus Sow., antiquatus, flemingii, var. burlingtonensis, longispinus DeK., spinosus, lobatus Sow., longispinus Sow., flemingii Sow., concinnus. Since the size even of the same undoubted species is so variable, from age or conditions favorable or otherwise in different localities, it cannot be safely depended on to characterize species. It may, however, throw light on the number of broods in a given time, or the periods of growth in a species when a great number of specimens can be compared.

The expansion of the front and sides beyond the visceral part is used to distinguish certain species, especially semireticulatus, but it occurs also in martini, tenuicostus, lobatus, flemingii and others, and we must conclude that these are all one species or that this peculiarity is not characteristic.

The relation of the length to the width is very generally mentioned in describing species. Yet by referring to the tables we find that at least three species: semireticulatus, flemingii, var. burlingtonensis, and lobatus are variously represented as having the length equal to the width, less than width and greater than width. Among specimens of flemingii from Visè, I found several with a raised band on the edge where the front was short, or in the centre of the front when this was so produced as to be greater than the width of the shell; and in one of these which showed both valves could be distinctly seen the proof that the raised band indicates the place where the dorsal meets the ventral valve and follows it to the edge.

Most shells seem to be broken off at this meeting point, thus making a shell, originally longer than wide, to become wider than long. And one of Sowerby's figures of P. martini shows a large crack which nearly separates the long expanded front from the visceral part. This visceral part alone is indistinguishable from DeKoninck's P. flemingii from Visè. (See Mineral Conchology, Agassiz's Edition, 1854, Pl. 317, p. 210.) The presence of the band on the front has been considered of sufficient importance to base

a new species upon it, the P. marginicincta; whereas in fact it is doubtless merely accidental.

2. Surface markings. Much stress has been laid upon the radiating costæ and concentric striæ or wrinkles on both the dorsal and ventral valves. In the descriptions tabulated, the dorsal valves of only two, costatus and semireticulatus, are found described and the same peculiarities of radiating costæ, concentric striæ and the nodulose appearance at their intersection, appear in each. Many more figures of dorsal valves are found, but there is a very monotonous, if not annoying, resemblance in them all. P. costatus is described by DeKon. as having, on ventral valve, radiating costæ which *do not bifurcate*, yet in specimens thus named by himself they *do* fork on both the dorsal and ventral valves, and this peculiarity belongs also to P. semireticulatus and P. flemingii, var. burlingtonensis. Costatus agrees with lobatus in the number of costæ, and with longispinus in their coalescing on the front. Four species—costatus, semireticulatus, flemingii, var. burlingtonensis, and antiquatus—correspond in having concentric striæ on their upper half. DeKoninck's description of P. martini gives it transverse folds on the beak, but Sowerby, in his original descriptions, separates martini from antiquatus, because the former is not corrugated and the latter is. (When doctors thus disagree who is to decide?) Again, flemingii and antiquatus are both described as having wrinkles on the ears, while the *figures* of not less than a half dozen other species show them, and the *specimens* of perhaps a half dozen more. These facts, with the statement of Mr. Meek, that costæ of the same species are often exceedingly variable (which can be easily verified by examining specimens in any considerable quantity), lead to the conclusion that we do not find in *surface markings*, the key to all these difficulties of classification.

3. In regard to *spines* also, equal confusion occurs. Hall gives as one characteristic of P. costatus, var., its row of spines in a curve from beak to base. This is seen on a few, but on many undoubted P. costati, equally well preserved, it is not to be found. And Sowerby describes P. martini in about the same way. Some of De Koninck's figures represent a P. longispinus Sow., with four rows of spines close together, forming a wide band from ear to ear, across the front just below the umbo. But among all DeKoninck's collections in Agassiz's Museum, I find only one marked at all in

that way, which is from Kaskaskia, Ill., while two of his semireticulatus from Chester, Ill., have rows of spines across the front. Hall describes flemingii, var. burlingtonensis, also, as rarely having a row near the base, but it does not appear on one specimen in a score in a large series of them. And, in short, my observations force me to conclude that what Dr. Shumard says regarding the variations in the spines of P. æquicostatus may be said with equal truth of almost any species: "In some specimens, they are separated from each other by pretty regular intervals, and arranged in oblique lines across the shell: in others they are scattered promiscuously over the surface." Mo. Report, p. 20.

4. Configuration of the valves. In the column devoted to the dorsal valve, five species are described as more or less flat, viz.: costatus, var. H., semireticulatus, flemingii, var. burlingtonensis, concinnus and antiquatus; four as concave, viz.: costatus Sow., flemingii, var. burlingtonensis, longispinus Sow., and longispinus described by DeKoninck, and said by him to be a synonyme of flemingii, lobatus, spinosus and setosa; and two as geniculate, viz.: semireticulatus and flemingii, var. burlingtonensis. Thus it appears that flemingii, var. burlingtonensis has all these peculiarities in itself. In the figures two are represented as flat, four as concave, and three as geniculate, but they are not uniformly the same species as were thus *described*, and the one that shows all these peculiarities is, in this case, semireticulatus. Respecting the configuration of the ventral, no essential difference appears among them all. Two are represented as "produced" and eight as convex. Yet *every* species must verify these same descriptions to belong to this genus at all. As a single instance of contradiction — selected from the many — I note that DeKoninck distinguishes costatus from flemingii by the flat form of its visceral part; while Hall makes semireticulatus, which I cannot distinguish from the European flemingii, flatter than costatus. Though much is made of the curvature of this valve by many authorities, it is not at all constant in the same species even from the same locality.

5. The *sinus* is said to be deep in four species, shallow and broad in six, and extending to beak and umbo in three; flemingii, var. burlingtonensis appears in two of these three groups, and longispinus, Sow., in all of them. Of specimens called by De-

Koninck longispinus, Sowerby calls those with deep sinus lobatus, and Phillips calls those with none setosa, while DeKoninck says the want of sinus is purely accidental. Hall says also that in one species, at least, it is inconstant, and examination of series of specimens proves that it is either present or absent in the same undoubted species.

6. The *ears* are represented as small in three species: costatus, flemingii, and longispinus; as extending beyond the width of shell in semireticulatus, and Sowerby gives triangular ears to longispinus, while DeKoninck makes them rectangular. The ears of costatus according to Sowerby, DeKoninck and Hall, are very small, yet in some specimens they are quite large and extended, and appear to have been broken or worn off in others. In DeKoninck's specimens of semireticulatus the ears extend beyond the width of the shell; but they are equal or less in his figures, and are not mentioned in his description. Hall in his descriptions and figures makes them much longer. So does St. John on his labels. This one peculiarity of the ears is the only one that semireticulatus has which is not presented by one or more other species; and since ears of species in general are often broken away on account of their thinness and much more frequently obscured by the matrix, and withal so variable under varying circumstances, they seem too unimportant a characteristic on which to base a distinct species.

7. The length of the *hinge line* is represented in four species as equalling the width of the shell, viz.: semireticulatus, longispinus of Sowerby and of DeKoninck, and lobatus; in five as less: (flemingii, var. burlingtonensis, flemingii Sow., longispinus DeK., antiquatus and spinosus), and in one as greater. Longispinus is variously described as having a hinge equal to the width, less than the width, and greater than the width.

Sowerby in his description of semireticulatus makes the hinge line equal the width, and uses this fact to distinguish this species from spinosus; but, so far as can be seen in a large series from Kentucky, it appears shorter, and these could as well be called spinosus, or even costatus, as semireticulatus. This peculiarity, therefore, could not be characteristic.

From these things it seems pretty clear that on no one point of description relating to external form and markings, can we rely for a satisfactory separation of species of this genus. And if we

take several of these together we are forced to the conclusion that a description of one species will answer essentially for several others.

II. Classification as to *Internal structure.*

This would, no doubt, be the best if not the only reliable means of distinction for species of the genus Productus if specimens showed their internal peculiarities in sufficient abundance.

The *cardinal process* is most frequently found and is resorted to, when other means fail, to characterize species. From all the information accessible to me, P. punctatus and vittatus have the boss bent at an angle to the plane of the dorsal valve. In some specimens bearing each name the deflection is a right angle, in others it is not, but most commonly so in vittatus. Some have the portion of the boss which is continuous with the plane of the dorsal flat on its surface, some are convex, some angular, and some grooved. The depressions for muscular attachment at the end of the boss are not the same in all by the name of punctatus and in some are indistinguishable from those on specimens named semireticulatus. In some of the species which do not resemble those just mentioned, the depressions are just like others called costatus, and those represented as belonging to this last species differ widely among themselves. I find also two specimens named tenuicostatus which show no differences in outward appearance, with bosses differing materially in shape. Two specimens named longispinus, one from DeKoninck's and the other from Davidson's collection, have neither their cardinal processes, their reniform nor muscular impressions alike.

The *retractor muscles*, or impressions and other markings revealing their presence, appear on a very few specimens. On P. punctatus two, three, and four undoubted indications of these muscles have been discovered; on P. semireticulatus two have been found.

The *adductor muscles* are much more frequently indicated upon the specimens, and also by the figures and descriptions of authors, and while I have examined all that have come under my observation, and made sketches of most of them, I experience about the same difficulty in finding any two alike as I would in the examination of human countenances. To be as brief as possible these remarks apply equally well to the *reniform impressions* and the *mesial septum.*

The *hinge area*, which is generally said to be wanting in this genus, is occasionally to be found, but I have observed it only in costatus and punctatus, most marked in costatus, and in all much more prominent on the ventral than the dorsal valve.

In my studies upon the internal structure of the Producti, some very interesting peculiarities within the beak of the ventral valve came to light. These tend to give plausibility to the belief that at least some species of Producti are possessed of a *rudimental proboscis*. In many specimens a sharp angular ridge appears within the cavity of the beak in the direction of the central line from beak to front, and is situated between retractor muscles of this valve. This is shaped like the ridge of a roof and gives the impression that its design is to protect some organ beneath. In some specimens it is much more sharply angular than in others. In examining other specimens, differently worn or broken at the beak, I found one in which appeared, at the same position in the beak, a very distinct, well formed and prominent spine. This pointed to the apex of the beak and is shown in figures representing it in different positions. That it is a rudimental proboscis I am not positive, though it is in the proper position for one if such existed. Also in the beak of a P. punctatus from Warsaw, Ill., a conical projection appears which is doubtless an indication of the same organ. But in another punctatus from the same locality a cardinal process is bent outward into the very apex of the beak of ventral valve, and comes in immediate contact with it. If this occurred in all specimens having such a spine there would be no room for a peduncle to protrude, but as no foramen is present in Producti it could only be projected when the valves are a little separated at the hinge, and this would leave sufficient room for it. As the anal aperture, as represented by Owen in Davidson's monograph, is in nearly the same position in a Terebratula flavescens, this *may* have been its position in Producti, and the spine or conical projection may be a cast of the anal passage, yet it is hardly probable that a cast of this should be formed, and hence we are left to the supposition of a peduncle as the most probable one. These appearances, however, are entirely too rare to be of any use in identifying species.

From examination of both external appearance and internal markings, therefore, the conclusion is reasonable that in neither

both do we find a satisfactory key to the separation of Producti o as many distinct species as are usually recognized, and that › best thing we can do, under the circumstances, is to group all › so-called species around a few characteristic centres according their affinities so far as we can determine them.

As a *provisional* arrangement which may at least indicate the ection in which satisfactory results may, at some time, be ched, I have collected the more common Producti into seven ›ups, and called them, Shumardianoid, Costatoid, Semireticu-oid, Tenuicostatoid, Flemingioid, Longispinoid, and Gigante-l. The species belonging to these groups are arranged in ›ular form so as to show their affinities to others in the same ›up and also to those in other groups, with a brief statement of ir differences.[2]

GEOGRAPHICAL DISTRIBUTION.

After months of careful comparison of all the specimens of Pro-cti to which I had access, both in the Museum of Comparative ology and elsewhere, I reached the conclusion, satisfactory to

The mere *names* of species classed in the different groups are as follows:—

COSTATOID. *Costatus Sow.*, Semireticulatus Mart., Flemingii, var. Burlingtonen-Hall, Mesialis Hall.

. SEMIRETICULATOID. Costatus Sow., *Semireticulatus Mart.*, Martini Sow., Anti-tus DeKon., Flemingii, var. Burlingtonensis, Fimbriatus Devreux, Concinnus Sow., theni Hall, Mesialis Hall, Lobatus Buch, Marginicinctus Prout, Setigerus, var. l, Arcuatus Hall, Carbonarius DeKon.

I. FLEMINGIOID. Lobatus Buch, Lasellensis Worthen, Semireticulatus Mart., *Flem-i Sow.*, Flemingii, var. Burlingtonensis Hall, Splendens N. & P., Elegans N. & P., bonarius DeKon.

r. TENUICOSTATOID. Semireticulatus Mart., Æquicostatus Shum., *Tenuicostus Hall*, a Owen, Pileiformis (Syn. of Cora), Altonensis N. & P., Prattenianus Norwood, ticus DeKon., Ovatus Hall, Setigerus, var. Hall, Marginalis, Keyserlingianus, Des-esianus DeKon., Carbonarius DeKon., Striatus Fischer? Arcuatus Hall.

. LONGISPINOID. Muricatus Phill., Nanus M. & W., Muricatus N. & P., Flemingii r., Parvus M. & W., *Longispinus N. & P.*, Lobatus Buch, Spinosus, Setosa, Car-arius DeKon., Wilburensis McC., Rogersi N. & P., Nebrascensis Owen, Elegans Kon., Splendens N. & P., Wabashensis N. & P., Scitulus M. & W.

I. SHUMARDIANOID. Tessellatus, Exanthematus H., Spinulicosta H., *Shumardianus I*, Subaculeatus Murch., Subalatus H., Murchisonianus, Concentricus H., Pyxida-H., Dissimilis Hall, Scitulus M. & W.

II. PUNCTATOID. Pyxidiformis, Fimbriatus Sow., Vittatus Hall, Nebrascensis en, *Punctatus Mart*, Pustulosus DeK., Scabriculus Mart., Leuchtenbergensis DeK.

III. GIGANTEOID. Magnus M. & W., Hemisphericus, Americanus Swal., Puncta-Mart., Pyxidiformis, *Giganteus Mart.*, Latissimus Sow., Striatus Fischer.

myself, that, from the material examined, there are four species, or typical representatives of groups, found alike on both sides of the Atlantic, and not more than four in sufficient numbers to be safely counted. These are costatus Sow., longispinus Sow. (which I consider a synonyme for semireticulatus Mart. and martini Sow.), flemingii Sow., corresponding to longispinus N.&P., and punctatus. The reasons for this conclusion I will briefly notice.

1. Costatus. By comparing size, etc., from all the data at my command, I find no perceptible difference between the U. S. and the European species, except that a *shade* of difference *may* be recognized in the ears; those of the U. S. being a little flatter than DeKoninck's from Ireland and elsewhere. The folded appearance of both is due to an elevated ridge on the inside of the dorsal valve, answering to a hinge plate, which extends into the ears. The difference is doubtless accidental or imaginary.

2. Semireticulatus. By comparison of the descriptions of P. longispinus, I find the only marked difference to be that European authorities make them larger than American. But on comparing the *specimens* bearing the name of longispinus, from different quarters of the globe and by different authorities, I find very remarkable differences. Among those identified by DeKoninck alone as in this species are seen very decided variations. In fact, a large majority of them from various European, and some American localities, are indistinguishable from P. semireticulatus of the U. S.; and among species, called by DeKoninck some longispinus and others semireticulatus, there is probably no difference whatever. One of DeKoninck's longispinus from Kaskaskia, Ill., which St. John calls flemingii, var. burlingtonensis, and which is the same as two of Worthen's semireticulatus from Warsaw, Ill., is identical with two of DeKoninck's semireticulatus from Chester, Ill. All have rows of spines across the front, wrinkled beak and umbo, ears equalling width of shell, the same shape, size, etc. One longispinus from Comblain au Pont and others from Yorkshire are the same as the last, but the spines across the front are worn down so as to be barely perceptible, and the costæ are a little finer; not, however, more so than in some undoubted semireticulatus. Among eighty-six of DeKoninck's longispinus I find only twenty-one which closely resemble the characteristic American longispinus. Most of the remaining ones differ from DeKoninck's flemingii only in being larger, and are

indistinguishable from P. semireticulatus of U. S. Hence I conclude that what are, across the ocean, called longispinus Sow., semireticulatus Mart., and also martini Sow., are the same as are here called semireticulatus Mart. DeKoninck's collection has also one hundred and fifty-six flemingii from Visè which are generally small, about half an inch wide, but otherwise closely resemble semireticulatus of U. S. Their uniformly small size may separate them, but I can see nothing in their resemblances that would put them with the U. S. flemingii.

3. Longispinus. DeKoninck makes P. flemingii, of Sow., a synonyme of P. longispinus Sow., and his descriptions agree essentially with Sowerby's original description. But most of DeKoninck's specimens from various European localities have only a slight resemblance to the typical U. S. species. They are much more like the lobatus, or longispinus of U. S. Out of over 350 named flemingii by DeKoninck, I found only eight or nine even approximately resembling this species of American authors, and about an equal number which might be termed transition species. Of these two are from Dunbar, three or four from Bollard, about five from Richmond, Yorkshire, and some half-dozen from Sunderland. Eighty-three from Dunbar very closely resemble lobatus, without spines. DeKoninck has also two from England and seven from New Mexico marked flemingii, which are the same as 125 specimens of P. longispinus from Ind., Ill., Iowa, Mo., Kan., Neb., and New Mexico identified by Worthen, Niles, Lathrop, and others. Some of these are with sinus and some without; the latter resemble P. muricatus N.& P.

From all the data I have been able to collect, I should say the trans-Atlantic flemingii are the same as the cis-Atlantic longispinus N. & P., and there are *no exact* representatives in Europe of the U. S. flemingii. Of the latter I have examined hundreds from Ky., nine from Chester group, of Chester, Ill., called elegans by Dr. Worthen, and seven other similar ones with Dr. W's label but no name, four in Barris's collection, from Littleglade, Ky., named striatus, N.&P., and four from Warsaw, Ill., labelled flemingii by Dr. Worthen (?), and three in Agassiz' Museum which resemble longispinus. One or two of the smaller specimens from Ky. are proportionately broader and with less prominent beak and umbo than most of the small and all the large ones from that locality, and are more like those of the same size in DeKoninck's collection.

This suggests the guess that, if the latter had grown larger, they might have greater resemblance to the Ky. specimens, though none of DeKoninck's large ones do very closely resemble them.

4. Punctatus. DeKoninck's specimens from Bollard, Visè, Yorkshire, Ireland, etc., are, without doubt, essentially the same as those from the U. S. The only difference I have been able to detect is a little greater concavity in the dorsal valve of the largest Ky. specimens, and the more variable size of the European, some larger than any I have seen on this continent (more than four inches wide with very tumid beaks) and some much smaller (not more than one-third of an inch wide). But of course these differences could easily be accounted for by peculiarities of their environment.

NOTE ON SPECIMENS OF PTILOPHYTON AND ASSOCIATED FOSSILS, COLLECTED BY DR. H. S. WILLIAMS, IN THE CHEMUNG SHALES OF ITHACA, NEW YORK. By J. W. DAWSON, of Montreal, Canada.

[ABSTRACT.]

THE author discussed the affinities of the plant published in the original New York Reports under the name *Filicites Vanuxemii*, which he had subsequently described as *Lycopodites Vanuxemii*, and had still more recently referred to his new genus *Ptilophyton*, but which has been referred by Professor Hall to Hydroids under the name *Plumulina plumosa*. Some new specimens, obtained by Dr. Williams, and found associated with stipes of ferns, and fragments of *Psilophyton*, as well as with some plants referable to the genus *Rhodea*, were described, and were held to show that the organism in question is really a plant, though possibly an aquatic one, and should be united with other similar species from the Devonian and Lower Carboniferous, in the genus *Ptilophyton*.

Some New Facts regarding the Fertilization of Yucca.

By Thomas Meehan, of Germantown, Pa.

In a paper I had the honor to read before the American Association in 1875, I observed that *Yucca* had then become a familiar example that some plants required external aid in fertilizing their flowers. The manner in which insects pollinize and effect fertilization in *Yucca* is still a matter of great interest to botanists. Dr. Engelmann has pointed out that the papillose termination of the stigma is made up of mere epidermal appendages, and the stigmatic surface can only be reached through a comparatively long and slender tube. Mr. Riley records that he has seen the *Pronuba yuccasella* thrusting pollen down this tube. With the exception of this observation I know of no other but my own which records how *Yucca* is fertilized. My own observations were read at the Buffalo meeting of the Association, and again confirmed in a paper at Saratoga in 1879. These were as follows:—in 1875 a plant of *Yucca angustifolia*, flowering freely, produced no seeds. In 1876 the early flowers produced no seeds; the later ones were each touched lightly on the papillose apex, with an own anther, and most of these produced seeds. These were those exhibited in 1876 at Buffalo, and were there cut open by Mr. Riley under the belief that they had been fertilized by *Pronuba*, and not by me; and that this would be confirmed if the larvæ were found in them. In 1877 what I believed to be *Pronuba* were found in the flowers. No artificial pollinization was attempted this year, and there was no seed. In 1878 the same course was adopted with the same result. In 1879 the application of pollen to the papillose apex was resumed, and the plant gave the quantity of capsules I exhibited at Saratoga. In 1880 the plant did not flower. This season the plant had three strong spikes of flowers, and it was determined to watch them critically so as to note the exact time of the insects' first appearance, and their behavior in the flowers. For greater security against error I engaged my brother Joseph, a good botanist and excellent observer, to watch the plant with me. The first flowers opened on the 10th of June. The first insects appeared on the 18th and the stem was marked at the last opened flower on that day. The pollen was applied to the apex from the first opening to the last flower that appeared. It is interesting to note that while a large number of those which flowered before the insects appeared have produced capsules, only one, and this imme-

diately following the other fertile ones, produced a seed vessel. Not one of all the other sixty-eight flowers which followed was fertile. Now if we had left off hand-pollinization when the insects appeared, and then left the matter wholly to them as we did in former years, we should have wondered how it was that if—as we know is the case—the flowers can be fertilized by the mere application of pollen to the apex, the active insects on their entrance and exit to the flowers did not carry some of the pollen to the apex, as we did by hand. But it was fortunate that we continued the work, for we found that though the seed vessels did not mature, the pollinization was effective in fertilizing them, and that nothing but a lack of vital power prevented the maturity of the capsules. The failure to mature seed vessels from the time of the appearance of the insects is a mere coincidence, though it is barely possible the visits of the insects, in some way as yet unknown, may have influenced the vital powers unfavorably. Here let me explain how we knew the flowers we pollinized were effectually fertilized; though I am anticipating a paper I hope to read at some future meeting on the rhythmic growth of plants. While the stamens and pistils are performing their tasks in nature, the growth in the pedicel is at rest. If the ovaries are not fertilized there is no more growth whatever in it. It soon dies away. But if the ovaries become impregnated, the pedicels at once assume motion, varying in the character of the motion with the species of the plant. In *Yucca angustifolia*, and perhaps in most species, the pedicel is pendent during anthesis; but when the time for motion occurs which follows impregnation, the pedicels assume an erect position. If the seed vessels fail to perfect after this, it is a failure of nutrition; or, as we may say, a weakened vital power, and not the lack of pollinization which is to blame. Thus we knew that in the erect and partially developed seed vessels impregnation had been effected. The discovery of this principle will prevent many erroneous conclusions in the study of the *Yucca* question.

The fact being established beyond dispute through these varied observations, extending now over many years, that the mere application of pollen to the papillose apex is sufficient for fertilization, there remains only the minor question of the identity of the insect referred to in these observations on the flowers of *Yucca angustifolia*. On their first appearance I supposed them to be *Pronuba yuccasella*, confirmed by a decision of Mr. Riley to whom I sent

ne specimen. Mr. Riley has since then discovered a new genus, asily mistaken for this one by a casual observer, and which he as named *Prodoxus decipiens*. As this one deposits its eggs in he stems of *Yucca*, and not in the fruit as *Pronuba* does, and no ruit of *Yucca angustifolia* has been found on my plants perforated, it was very natural to suppose the earlier determination a mistake, and that these were *Prodoxus* and not *Pronuba*. To determine this matter I sent all the insects I caught in one flower to Professor Hagen, the eminent entomologist of Cambridge, Mass., who reports them to be of both genera: four of *Pronuba*, and thirteen of *Prodoxus*. A very singular circumstance however was that every one of both genera was a male!

It is evident from the facts I have detailed, that there is much more beneath this subject of the *Yucca* and the *Yucca* moth than has yet been developed. It is one eminently worthy of closer study; and I trust that the few positive facts I have been able to establish will be of some aid to those who may follow me.

THE MOTION OF ROOTS IN GERMINATING INDIAN CORN. By W. J. BEAL, of Lansing, Mich.

[ABSTRACT.]

MR. Charles Darwin says in reference to experiments which he has made that, "in whatever direction the primary radicle first protrudes from the seed, geotropism guides it perpendicularly downwards."

I have carefully studied over four hundred kernels of sprouting Indian corn of seven different varieties, and so far as they are concerned, Mr. Darwin's statement is much too strong. Kernels of germinating corn were placed in all *sorts* of positions over a pan containing water which was covered to keep out the light. In a great many cases, the primary root (radicle?) makes one or more coils in its descent. In some cases, it passes in nearly a horizontal position; in one instance for a trifle over three inches. In other cases it went nearly directly upwards for an inch or more, then it made one, two or even three revolutions.

On a flat smooth surface of a plate, it often crept along without deviating from its course, while in several instances it made two or three up and down motions not unlike waves on the surface of water. Small pieces of gum-paper placed near the tip usually caused the root to bend in an opposite direction, but in some cases no such effect was produced. Young roots are more sensitive than old ones.

PHENOMENA OF GROWTH IN PLANTS. By D. P. PENHALLOW, of Cambridge, Mass.

[ABSTRACT.]

THE very striking movements to be noticed in certain organs of many plants, as well as those which cannot be readily detected but which, in all probability, are common throughout the vegetable kingdom, are now well known to be the simple manifestation of normal growth, a result of the various physiological processes within the plant, or, as in the case of movements produced by contact of some foreign body with the sensitive tissues, they appear as a natural result of disturbing the normal vital processes. In like manner are we to regard the movement of sap after the leaves are developed, and the power of a plant or its part, not only to sustain, but constantly to raise a daily increasing weight until thousands of pounds are lifted and the limit of the power thus manifested, is found only in the ability of the tissues to resist decay, which sooner or later makes its appearance as a natural result of the very unusual conditions to which the plant must be subjected.

Darwin, in his several works, has shown, in a very careful and painstaking manner, how the movements of plants are produced or modified in certain organs by various mechanical influences, as well as by some of the natural influences to which the plant is ordinarily subjected. He has also shown us what directions these movements take and the figures they describe, and to his first paper on "Climbing Plants" in the "Journal of the Linnean Society," for 1865, was due the suggestion that, if these movements are but normal manifestations of growth dependent upon the perfect maintenance of the vital condition of the plant, they must necessarily be affected by whatever operates in any manner—whether to augment or diminish—the physiological changes in, and condition of, the plant as a whole; and therefore, that they must afford a ready means of determining the effect of varying meteorological conditions upon growth and those which are best adapted to its promotion. It was, therefore, with this idea in mind, that experiments —the results of which are here given—were undertaken, and it was recognized as of prime importance that, to secure results which should be of value, the plants must be grown in the open air and

[1] Phenomena of Plant Life: W. S. Clark.

ler the conditions to which they would be naturally subjected. was also desirable to select a plant of vigorous growth in which vements were sufficiently pronounced and rapid to permit of quent and accurate observation. The mammoth squash was nd to answer the requirements better than any other plant obnable, and, accordingly, some of the seeds were planted in a efully prepared lot sufficiently removed from trees and buildings prevent the plant from being subjected to any but the normal nditions of light, air, temperature and humidity. Through varian in movement of the tendrils and terminal bud, rate of growth the vine, and weight of the squash, a knowledge of the conditions orable and adverse to growth was sought, and to accomplish s satisfactorily, every observation recorded was accompanied by ord of local temperature, humidity, cloud, etc.

TENDRILS.

The tendril is a modified leaf, and consists of five long, slender ns borne upon a rather stout and short stalk closely resembling hortened petiole. The arms are from eight to twelve inches in gth. They are at first rolled up compactly, but very soon after erging from the terminal bud begin to unroll, the central arm—ich is the longest—becoming straight and commencing its muions first. Later, the lateral arms straighten and become ac-, and by thus having its period of activity prolonged, the dril is enabled in the best manner to perform the functions for ich it is specially designed. Thus, the long central arm may sp an object before the short laterals are fairly in motion. It n draws the whole plant laterally toward the point of support l enables the shorter arms to take hold, when they in turn w the plant up to a still firmer support. As the tendrils arise m alternately opposite sides of the vine at succeeding nodes, vine is constantly drawn first to one side and then the other, l finally becomes held between strong but elastic supports as tendrils coil up into double spirals and become hard and ody.

The form of each tendril arm is that of a long filament well nded on the lower surface, but flattened and slightly channeled ve. The extremity, for a distance of half or three-quarters of inch, takes a more perfectly cylindrical form and turns slightly

upward. The tissues are chiefly parenchymatous, though there are two woody bundles extending the entire length. The upper surface, though not very sensitive, is the only one affected by irritation; and a curve, produced by contact of some foreign body with it, is reversed only after the lapse of some time, when, by continued growth, the opposite sides become equal in length.

The movement commences before the tendril arm is fairly straight, and once active, its nutations are seen to be controlled first, by the activity of its own tissues, and second, by the influences which affect the plant as a whole, and thus waves of growth or movement, of greater and less activity, succeed one another continually.

The nutating tip describes a figure which is really the resultant of two movements, *i. e.*, one at right angles to the tendril axis, the true motion of the tendril; the other parallel with the tendril axis, due to lateral movement in the growing extremity of the vine, and a true record of nutations would be obtained only by allowing the tip to pass about the inner surface of a glass globe, marking changes of position from the outside. For our purpose, however, it is sufficient to obtain only that motion which would be recorded on a plane surface placed at right angles to the tendril axis. The figure thus described, Darwin speaks of as ellipsoidal, and if the points where change of direction occurs are connected by curved lines, this will sometimes be found to be true, but in the case of our squash it was found that the changes of direction were often so frequent and exactly reversed, that in the majority of cases, not even an approach to an ellipsoidal figure could be obtained. This, however, is of minor importance; that which calls most strongly for our consideration being the rate of movement, ratio of right hand to left hand movement, and influence of light, temperature and moisture. Assuming the figure to be a sort of ellipse, we find that the major axis—which is horizontal—not unfrequently reaches a length of 24-27 c.m., and the minor axis a length of 13-22 c. m. This wide lateral range supplemented, as it is, by the movement of the vine, adds greatly to the probability of the tendril coming in contact with an object it can grasp. Failing to seize a support, the tissues become hard and woody in the natural course of growth, and the tendril at the same time gradually coils upon itself and becomes useless.

From a record of 436 complete and distinct observations taken

luring every hour of day and night for one week, we find the aveage rate of tendril movements to be 0.316 c. m. per minute. The most rapid motion observed was at the rate of 6.5 c. m. each minute, and the slowest movement was only 0.013 c. m. per minute. It was furthermore found that movement was more rapid with increasing heat and less with falling thermometer, so that other things being equal, the greatest movement would be observed during the warmest days. On the other hand, however, it was noticed that increasing humidity favored rapid movement, while a dry atmosphere produced the opposite effect, and as the relative humidity of the air at any one time might be small through great elevation of temperature alone, we find that, while increasing heat is beneficial, it is so only when the relative humidity likewise increases in such proportion that *excessive transpiration from the plant does not occur;* otherwise high temperature operates to retard growth and movement by weakening the vitality of the plant.

The effects upon movement of alternations of day and night are not to be looked for as the result of variations in light, but as produced by different conditions of temperature, though from the retarding action which light usually exerts upon growth, we might expect that, other things being equal, movements would be more rapid during the night. The figures obtained, however, show that for an equal number of hours of day and night, the movement during the former was 1359.9 c. m., and during the latter, 536.9 c. m. an excess in favor of day which is clearly attributable to the influence of increasing heat as being much greater than the absence of strong light. This, as well as other facts of a similar nature, to be spoken of later, coincides with the observations of Rauwenhoff, who found that growth in *Cucurbita pepo* for twelve hours of day was 56.9 per cent. against 43 per cent. for the same number of hours of night.

The movement of the tendril arm is explained by supposing the greatest growth to lie within a band of cells which extends from base to tip of the tendril, thus bending the latter toward the opposite side. If this band of growth passes regularly around the tendril, then the nutating tip will describe a figure which approaches a circle or ellipse; but if the band of growth arises without regularity, first on one side and then on the other, the tip will describe a correspondingly irregular figure, and this is what ap-

pears to occur in the case of *Cucurbita pepo.* Looking from base to tip of the tendril, it seems proper to designate the movements as dextrorse or right hand, and sinistrorse or left hand. The movements of the tendrils during the time of observation aggregated 3023.05 c. m. Of this 1622.1 c. m. were dextrorse and 1,400.95 were sinistrorse, a ratio of 1 : 0.86.

These movements right and left are not the result of torsion, for there is none; they are due simply to change in position of a band of strong growth, and the figures here given go far to show that growth is equal upon all sides.

TERMINAL BUD.

In the terminal bud of the vine there is also a well defined movement; due, first, to increasing length which, making the unsupported part too long for its strength to bear up, allows the tip to fall toward the ground. Continued growth brings the tip up again, and thus is produced a vertical motion; second, to the fact that all the lateral members being chiefly upon the same side of a particular node, growth will be greatest there and the tendency will be to bend the vine in the opposite direction. This is seen in the zigzag form which the plant finally assumes, and gives to the tip a lateral motion as the vine bends in opposite directions. We observe here, that the movements were subject to the same variations under like conditions as were noticed in the case of tendrils. The average rate of movement was found to be 0.065 c. m. per minute; the maximum rate 0.42 c. m., and the minimum rate 0.013 c. m.

GROWTH OF VINE.

Variations in growth of the vine were found to be governed by heat, light and humidity in just the same manner as noticed in previous cases. During 158 hours of almost uninterrupted observation, the whole growth was found to be 89.5 c.m., giving an average hourly growth of 0. 566 c. m. The most rapid growth was at the rate of 1.16 c. m. per hour, and the slowest growth 0.0 c. m., this occurring but once. Equal number of hours of night and day showed the ratio of growth to be as 1 : 1.3, a ratio in striking conformity with the results of Rauwenhoff, already noticed, which show the relation to be as 1 : 1.32.

To make the relations indicated yet more manifest, we may plot the curves of growth together with those for temperature and humidity, and throughout, it will be found that there is a striking coincidence—great heat waves having correspondingly great waves of movement and the reverse.

CONCLUSIONS.

In the limited space to which we are confined, it is not possible to give the experiments more in detail, desirable as that perhaps might be, but the facts obtained are sufficient to permit of some deductions in confirmation of those obtained by others.

Movements of plants are not manifestations of instinct, will power, or intelligence, as has been claimed by a few whose sole aim it was to make capital out of a credulous public, but may be readily and properly accounted for as the natural result of variation in growth under the influence of external conditions as affecting the vital processes. Whether in the leaf, tendril or branch, wherever there is regularly recurring and normal motion, we may in most cases, perhaps all, speak of it synonymously with growth, and in this sense we will regard it in the following lines:

1st. Movements of tendrils, roots, leaves and terminal buds, being phenomena of growth, are modified by whatever variations of condition affect growth.

2d. Growth is promoted by an increasing temperature, humid atmosphere and absence of strong light.

3rd. Growth is retarded by excessive transpiration, low temperature, dry atmosphere and bright light.

4th. The conditions to which a plant is normally subjected being variable, there is a corresponding periodicity in the vital phenomena.

THE WHITE PINE OF MICHIGAN. By WILLIAM HOSEA BALLOU, of Chicago, Ill.

[ABSTRACT.[1]]

FORTY-SIX years ago the pine lumber industry of Michigan had its origin on the Saginaw river. From that date to the present, the denudation of timber has increased in that state, and other pine areas, to such an extent, that within the next decade the use of such material in commercial pursuits must pass out of existence.

The first thought suggested is relative to the origin of the white pine forests. Whence came the species which so strictly confines itself to its own peculiar territory? The oak, and most other trees, are naturally reproductive, and young trees are equally prolific in their growth on the same soil where the first forest was razed to the ground. They may be transplanted on almost any territory, and without any special care, speedily growing up to a state of usefulness to man. Not so with the white pine. It is now an almost undisputed fact that it will not reproduce on the parent soil, and that when transplanted elsewhere, its development is marked with early decay in so many instances as to disparage the work. Furthermore, it is beset at once with the same host of natural enemies common to it on its indigenous ground.

The pine of the level country east of the Rocky mountains seems to have its best growth in proximity to the lake region. I have noticed that frequently, where a lake recedes, leaving a sandy beach, evergreens, the juniper, pines, etc., are very apt to spring up. Within the memory of man, a wide sand beach near Waukegan has been made, and on this area a miniature white pine forest has appeared, and thrives. On some lone islands in Lake Erie, of evident recent formation, called the East Sister, the Old Hen, etc., I observed several years since that a similar phenomenon had occurred. These and other facts point to a recent origin of the pine forests under consideration, which might not have been in existence at the time of the landing of Columbus. This fact is more apparent when it is stated in this connection that the average age of the pine is less than 300 years in this country; and the other fact is

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'eiterated that it does not reproduce on the same soil. The pres- :nt pine forests, then, doubtless took the place of some other spe- :ies, which had exhausted the soil necessary to their existence, a »henomenon well-known to naturalists.

The next question of importance is reproduction. Answers to |ueries submitted to over one hundred practical lumbermen, as rell as careful observation, make positive the fact that the repro- luction of the white pine on parent soil is impossible as a com- nercial success. There are reasons for this. The most important ıas relation to the exhaustion of that vitality of the soil necessary .o this species. Other causes have been advanced to the neglect »f this, which plainly do not bear on the case. Were reproduction uccessful—and here is the great practical proof—my one hun- lred informants say that long ago forests would have been started :o replace those now a fact of the past.

The enemies of the white pine are numerous. The average of he data I have gathered tends to show that pine forests began to ecay before one-half of the trees were matured. The causes of uch decay are the growth of punk or rot, "wind shakes," and ›ose knots. Insects do not originate, but hasten decay.

The punk is a rot which appears in a lump on the side of the 'ee, eating into its vitals. It is due to more than one cause. 'pinions of writers vary on this subject, all of whom argue in be- alf of a special cause. I have carefully examined all of these laims, but observations in the lumber regions, and talks with lum- ermen, have convinced me that anything which affects the vitality f the tree will produce punk or rot.

Enemy number two is the black knot which, when the tree is awed, drops out of the board, making it defective. It is caused y its imperfect growth. If there is not sufficient nourishment at he roots to support the limb, it grows imperfectly, and its inner ermination works toward the heart, as if to suck sap from the itals. This brings on loose layers and subsequent decay.

A wind shake is one of the exasperating defects of lumber. It s noticeable in a board, the layers of which separate, usually in :riangular form, when the sawing takes place. It occurs gener- ally on the butt of the tree, and is caused by the force of the wind when the tree is standing, and by frost when the log rests in the yard.

All parties agree that from one-half to one-third of the lumber product is destroyed by fire. Fires, where they occur, follow

clearings, but often penetrate the dense forests, sometimes covering an area of a hundred square miles. It is impossible to secure any data on this subject, because more or less lumber is saved out of the wreck. A pine tree that has been scorched is utilized the succeeding year, or the worms destroy it.

Insects are very destructible, the pine weevil, *Tomicus xylographus*, being a foremost agent. These attack a sound tree, but not a live one. If any one will take the trouble to enter a great log yard at dusk, these creatures may be heard at work, the united sound of which is like the roar of wind or water. The grub goes through a log in a crooked line, which greatly depreciates the value of the timber. There is a "pin worm," the scientific name of which has escaped me, that bores its way straight to the heart, leaving a round black passage the size of a pin head. These are the only insects which lumbermen take into account in Michigan.

The white pine does not furnish so rich a quality of pitch as the yellow pine of the south. It has but little market value. It is sometimes gathered for medicinal purposes, melted, cut with spirits, and used for throat diseases. Some people use it for ague, but so much whiskey is mixed with it that the scientist pauses on the threshold of doubt as to whether the whiskey is used to save the pitch, or the pitch to secure the liquid.

A pine tree grows from ninety to one hundred and sixty feet in height, the average being one hundred and twenty-five feet.

A log sixteen feet long will average 250 feet of lumber, although one log has been known to produce 2,500 feet.

The diameter of an average log is thirty inches; the maximum, six feet.

A pine tree begins to branch about two-thirds of the way to the top, though often branching at the top only.

The facts give rise to a general formula, that a tree is no greater than its roots. The expanse surface of roots of the pine correspond closely with its height and outer surface. Although much crowded in a dense forest, the roots of an overturned tree have been known to yield a surface of 1,600 square feet.

Pines grow usually on high ground, in sandy soil, but best when the latter is mixed with clay.

The waste branches of the pine tree are not utilized to any extent except as fuel.

Pine sawdust is now being used to make paper pulp, and packing, and in other ways is a commodity.

The heart of pine resists to the last all injurious causes which operate on the outer layers.

Windfalls are severe agents of destruction, as speedy decay follows.

The following items relate to the pine lumber industries of Michigan. In 1835 there were 150,000,000,000 feet of lumber on 20,000,000 acres of land. Since that time 115,000,000,000 feet have been cut. On the Northern Peninsula there now stand 6,000,000,000 feet on 4,000,000 acres. On the Southern Peninsula are 29,000,000,000 feet on 6,571,000 acres. This leaves a total of 35,000,000,000 feet on 10,571,000 acres. Some 5,000,000,000 feet are now annually taken, so that in seven years the supply will be exhausted. In this industry, in 600 mills are 150 gang saws, 600 circular saws, 100 mulays, and 500 edgers, with a total capacity of 5,000,000,000 feet per annum, and valued at $11,750,000. There are 800 vessels engaged in the transportation of this lumber, occupying 4,800 men, and valued at $5,000,000. In the log woods in winter, 50,000 men are at work, and 20,000 in the mills in summer. There are 30,000 animals thus engaged, two-thirds of which are horses, and the remainder oxen. There is a total of 75,000 hands engaged, 30,000 animals and a total capital invested in vessels and mills of $16,750,000. The lumber taken since 1835 has sold for $1,500,000,000.

The ancient lower limit of the white pine belt extended from Grand Haven to Port Huron, dipping on the west side of the state to Kalamazoo. The whole pine area now comprises 288 townships in eighteen counties, in the Lower Peninsula, embracing 10,268 square miles, or 6,571,520 acres; and in the Upper Peninsula 179 townships, or 4,124,160 acres.

It almost seems like despair when one hopes ever to raise forests for another such enormous production. Science will doubtless devise other materials to take its place. Indeed, I have been shown a material, made in Chicago, in shape of a board one inch thick, from wheat straw, which may be colored to represent any lumber now known, so accurately as to deceive the eye. The inventor manufactures 2,000 square feet of this from every ton of straw. It is more durable and much cheaper than lumber. As a parallel to the use of paper wheels, Mr. Pullman is now finishing off three palace cars in this material. The limit of its production will depend only on that of wheat straw.

INFLUENCE OF FORESTS ON WATER COURSES. By DAVID D. THOMPSON, of Cincinnati, Ohio.

[ABSTRACT.]

A LARGE quantity of rain as it falls is intercepted by the leaves of trees, and the roots, by keeping the soil around them loosened, induce the speedy absorption of most of that which reaches the ground, much of which, but for the trees and their effect upon the soil, would immediately flow away.

The foliage of trees, by partially or wholly excluding the sun's rays, prevents, to a great degree, the evaporation of the water in the soil, which in a treeless region soon renders the ground as destitute of moisture as though no rain had fallen.

By the absorption by the soil of the rain as it falls, the flooding of the streams is largely prevented; and by retaining the water in this natural reservoir, and allowing it to flow off gradually, the streams are supplied with water continuously.

When the pioneers settled the lands in the eastern and middle states, they were covered with forests, and the first and most important work of the new settler was to cut away the timber, in order to get land upon which to raise food for himself and family. For many years there was, of course, no apparent effect upon the water-courses; but as the number of settlers increased and the amount of forest land decreased, the springs began to dry up, and with them the brooks, and creeks, and smaller rivers.

It is not unusual to find in many localities the beds of what were once important mill-streams waterless, except when filled by sudden freshets; and in this state (Ohio) certain streams emptying into the lake, which were once declared navigable, will not now float a canoe. Previous to 1832 Captain Delorac, of Hamilton, Ohio, annually sent a fleet of flatboats down the Big Miami river at the spring rise; but with the destruction of the forests along that river, the rise became so uncertain that the enterprise was of necessity abandoned. Professor Newberry, in his Geology of Ohio, states that the Ohio river has been getting lower and lower, in dry seasons, for many years. During 1871-1872 the Ohio sank lower than had been known before, and at Smith's Ferry, where the Pennsylvania line crosses, a ledge of rocks was laid bare that had not been seen or heard of by any people living in that vicinity.

Lapham says that "such have been the changes in the flow of the Milwaukee river, even while the area from which it receives its supply is but partially cleared, that the proprietors of most of the mills and factories have found it necessary to resort to the use of steam, at a largely increased yearly cost, to supply the deficiency of water-power in dry seasons of the year. The floods of spring are increased until they are sufficient to carry away bridges and dams before deemed secure against their ravages. What has happened to the Milwaukee river has happened to all other watercourses in the state from whose banks the forests have been removed; and many farmers, who selected land upon which there was a living brook of clear, pure water, now find that the brooks dry up during a considerable portion of the year."

The effect upon the larger rivers is no less marked. In a pamphlet republished by the United States Government, Gustave Wex, councillor of state of Austria, gives an exhibit of the average annual decrease in the height of the water in a number of rivers. These observations extended over a number of years, and show that the sinking of the water surfaces has become much greater in the last two or three decades than formerly. This is explained by the fact that during these years there has been a greater amount of clearing, drainage of ponds and marshes, and improvement and irrigation of large tracts. The average decrease, while not large, is alarming, inasmuch as it shows the possible danger in the future.

In the same pamphlet it was stated that the volume of water at the lowest stage of the river Sele has decreased 33 per cent. during the last 150 years; that of the river Brenta, at Bassano, seven per cent. between 1864 and 1877, and that of the river Adda, where it flows out of Lake Como, 13 per cent., between 1843 and 1862, due in each case, says Senator Torrelli, of Italy, to the clearings around their feeders.

A remarkable illustration of the fact that the clearing of hilly countries is likely to result in the complete failing of springs is given by Mr. Ney, who states that in the Provence, after all the olive trees, which there formed regular forests, had been frozen in 1822 and cut down, a great number of springs failed totally; and besides, in the city of Orleans, after the surrounding heights had been thus cleared, nearly all the wells dried up, and it became necessary to conduct the head-waters of the river Little Loire into the city.

At the International Congress of Land and Forest Culturists, at Vienna, a few years ago, it was stated that there had been a gradual decrease in the depth of the large streams of all countries. In some cases, it was said, rivers, which in former years had been of considerable magnitude, had entirely disappeared. The Rhine, the Elbe, and the Oder are all shallower than formerly. The waters of the Elbe had diminished in depth ten feet in fifty years. The decrease in the waters of the Elbe was attributed to the reckless destruction of the forests of Bohemia, where it rises, while that of the Rhine was attributed to the felling of the trees in Switzerland, where are found the sources of that famous river.

But history and observation tell us some things that are more impressive even than the statistics of scientific investigations. Every reader of Bible history and geography knows that for centuries Palestine abounded in little streams, and from nearly every hill gushed forth water. But this is not the case to-day. While the channels of these streams remain, they are totally dry, except in the rainy season. That water was formerly abundant is evidenced by their great number. And the absence of trees in Palestine is to-day as marked as the absence of water in these dry channels. Recent explorers have also expressed the opinion that the cutting away of forests along the Jordan and other tributaries of the Dead Sea has so reduced the water in that sea that the influx has not for many years been equal to the evaporation, and that the sea level is in consequence much lower than before the time of Christ. In the days of Babylon the Euphrates was so bountifully supplied with water that not only did it inundate the fields and spread over the plains, like the Nile, but it rendered necessary great precautions to prevent the famed city from being washed away by its waters. But this is not so now. A traveller, M. Oppert, says that the Euphrates does not now fill its banks; the canals which were used to divert its waters from the cultivated fields are dry; and the marshes become dry during the powerful heats of summer. This diminution of water he ascribes to the clearing off of the forests on the mountains of Armenia.

M. Becquerel, in his essay on the "Climatic Effects on Forests;" gives a number of instances of similar effects. M. Laussure, he says, notices the diminution of waters in the Swiss lakes as a result of clearing, especially in lakes Morat, Neufchatel, and Bienne. Choiseul Gouffier was unable to find the Scamander river, which in the time of Pliny was still navigable. Its bed is now entirely

and the cedars that once covered Mount Ida, where it took its no longer exist.' The history of Ovideo and the observations [umboldt show that, owing to the removal of the forests, the of New Valencia, in Venezuela, at the time of his visit, was much farther away from Lake Tacarigua than when it was settled, and that the waters of the lake had receded to the extent. Boussingault, in 1822, learned from the inhabitants the waters of the lake had risen, and that lands formerly culed were under water. Previous to that time there had been a ty-two years' war, during which the population in the valley lecreased, the lands were uncultivated, and the forests, which e tropics grow with great rapidity, had been restored. Ben 1826 and 1830 the inhabitants of the metalliferous moun- of Marinato increased from a few negro slaves to three thouworkmen. Numerous establishments were erected, to supply h, and for other necessary purposes, much of the wood had cut. Within two years the effects of the clearings were seen e decrease of the waters used in driving the mills, and that, while a rain-gauge showed that a greater amount of water had n during the second year than during the first. The lakes in 'alley of Mexico have greatly contracted since the time of the cs. The city of Mexico formerly stood on several islands in Tezcuco. Largely in consequence of the removal of the ts that in ancient times clothed the neighboring hills, the has receded, and the present city, though occupying the same is now over two miles from its shores.

it while the more level lands need to be, in some degree, covwith trees, in order to prevent the extremes of floods and ght, this is especially the case with mountain lands.

ie evil results of the cutting away of mountain forests are especseen in the valleys and plains of the Alpine regions of France, ', and Switzerland, where torrents have wrought fearful destruc- M. Gentil says that torrents are one of the most disastrous ues of the high Alps, and Surrell says that the wild waters flown broad sheets over the surface of the ground, without bed, out ravine, have destroyed villages and ruined whole districts, h have been abandoned.

ie history of France abounds in illustrations of the destrucpower of these mountain torrents. The floods in the valley of Garonne, six years ago, destroyed, it is estimated, fifteen thou- lives. The losses of life and property caused by these tor-

rential floods induced the French Government, a few years ago, to take steps to reclothe the mountains with trees and vegetation. It is estimated that it will take one hundred and fifty years before the work contemplated is fully accomplished; but encouraging results have already followed the little that has been done.

J. Croumbie Brown states that like damage, only in less degree, is done by the mountain torrents of South Africa. One which occurred in 1868 damaged public property alone to the amount of $250,000, and private property about half a million dollars. By the floods of 1874 damage was done to the public works alone amounting to about a million and a half of dollars.

Illustrations showing the great loss of both life and property occasioned by torrential floods could be multiplied indefinitely, but the few cited ought to be sufficient to show that they are a calamity which great pains should be taken to prevent. That they are possible in the mountain regions of the United States was shown by the recent disastrous flood in Pennsylvania, when streams rose so rapidly that people were glad to escape with their lives, and lost property valued at several million dollars. While it is not to be supposed that torrents can be wholly prevented by mountain forests, it is certain that they can be modified to such an extent as to prevent their doing such serious damage.

But there are possible results following the drying up of the streams through the unlimited destruction of forests that should alarm the American people, and cause them to make greater effort to preserve the forests in localities where they now exist and their cultivation where they do not. How terrible these results may be is seen in the desolation wrought upon Babylon, Nineveh, Thebes, Memphis, and especially upon the people of the Chinese province of Shan-Li only three years ago, by the loss of their forests. History shows that not a few nations have declined with the disappearance of their forests; and upon the preservation of our watercourses may depend our existence as a nation. While the government ought to protect its own forests and especially its own mountain forests, it is the farmers and other small land-owners who can effect the most good; and every influence possible should be exerted to induce them to reclothe a portion of their denuded lands. In this work the most effective agency would be the press, particularly the agricultural press; and it is to be hoped that it will agitate the subject until the desired result be brought about.

ON THE INFLUENCE OF THE STRUCTURE OF THE NERVE-FIBRES UPON THE PRODUCTION AND CONDUCTION OF NERVE-FORCE. By H. D. SCHMIDT, of New Orleans, La.

IN studying the various physiological phenomena, which manifest themselves through the medium of the nervous system, the question as to the mysterious agency, causing these manifestations, as well as to the particular mode in which it operates, naturally presents itself to our mind. The older theories of the nature and propagation of nerve-force, based upon vague speculations, represented the nervous phenomena as caused by some physical agency, or principle, such as a nervous fluid or gases, running through the nerves; and it was not until the discovery of electricity that nervous force commenced to be regarded as identical with this agent, a view, which was finally corroborated by the discoveries of Galvani, and his contemporary investigators, of the electrical phenomena of animals. For Du Bois Raymond, however, it was left to show, as late as 1843, that in every portion of nerve, in a living excitable condition, an electric current, originating in the nervous substance itself, passed from its surface, or longitudinal section to the transverse, from which it returned through the nerve to complete the circuit. Nearly at the same time, this physiologist also discovered the so-called *electrotonic* condition, or "*electrotonus*" of the nerves, a discovery which greatly advanced our knowledge of the inherent properties of these nervous organs, and facilitated the investigations relating to the true nature of nerve force.

The observed fact that from the molecules of every part of the longitudinal section, or surface, of the nerve, an electric current passes to the nearest transverse section, thence back to the former, forming a circuit through the nerve, gave rise to the idea that each nerve, or, better said, nerve-fibre, consisted of innumerable electro-motor elements, each of which possessed a positive equatorial, and two negative polar zones; and that these elements, surrounded by an indifferently conducting liquid, were arranged in such a manner, as to present their positive equatorial zone to the longitudinal section, or surface, while their negative polar zones were directed toward the transverse sections. But, in order to explain the different phenomena presented by the nerve when in the electrotonic condition, this peripolar theory was modified so far as to make each of the peripolar elements consist of two di-

polar molecules, the positive poles of which were to point toward each other. And, in accordance with this supposition, the increase of strength in the natural electric current of the nerve at rest was explained in presuming that the polarizing current, while passing through the nerve, caused the electrical unlike particles of the latter to arrange themselves in an order, similar to the elements of a Voltaic pile; in other words, that the positive poles turned toward the side to which this current is directed, the negative toward the side from which it comes. The polarization of the nervous molecules, therefore, was to be regarded as an electrolytic process, causing the negative poles to turn toward the positive, and the positive poles toward the negative electrode.

At the time when the above theory was established, the preëxistence of the axis-cylinder of the nerve fibre was still a disputed point; and, accordingly, the theory was based upon the supposition that the entire double-bordered nerve-fibre consisted only of a basement-membrane tube, the so-called membrane of Schwann, filled with a homogeneous nervous substance, or matter. The sympathetic nerve-fibres, representing naked axis-cylinders, were hardly known as such, but were generally looked upon as a kind of connective tissue. Aside from the objections, however, which, at present might be raised against the above theory, it was insufficient to explain some of the phenomena pertaining to the electric condition of the nerve, and, for this reason, it lost its popularity and was finally displaced by more recent theories, the most prominent of which was the so-called theory of "*liberation*," or "*discharge*," of Phlueger.

This is based upon the supposition that in the molecules of a nerve a certain amount of potential energy is always present to be converted into kinetic energy; and, furthermore, that there are two antagonistic forces exerting their influence upon these molecules which are constantly inclined to motion. One of these forces is supposed to cause the motion of the molecules, while the other is believed to inhibit it. In the nerve at rest, the forces balance each other, while in the state of activity, the inhibitory force diminishes, and thus determines the degree of force liberated by a given stimulus. Accordingly, in the anelectrotonic condition of the nerve, the force inhibiting the movements of the molecules increases, while in the cathelectrotonus it diminishes. The propagation of the nerve-force, finally, is explained by each nervous elemen

liberating from its neighbor a certain amount of force, which increases with the continuation of the process.

Though a number of other theories regarding the mode of production and propagation of nerve-force have subsequently been advanced from time to time, that part of Phlueger's theory, which explains the production and conduction of the force in question as being effected by each nervous element liberating a certain amount of potential energy from its neighbor, the whole representing a chain of liberating processes, was generally accepted.

Hermann, who regards the liberated forces as chemical in their nature, sums up the more recent theories on the subject as follows: in every nervous particle, he says, a certain substance, containing potential force and being inclined to part with the energy it contains, splits during its state of activity; and, in consequence of his splitting, the same takes place in the neighboring element. The process of conduction in the nerve, therefore, is comparable o that going on in a train of gunpowder fired at one end; though, n order to understand why the whole store of potential force present is not consumed at once, as in the case of the powder, the presence of some inhibitory force, in some form or other, must be presumed.

It is a notable fact that in all the theories on the nature of nerve-force, be it the liberating or the preceding dipolar, the anatomical structure of the nerve-fibre, such as it has been revealed by modern histological researches, has never been taken into account; on the contrary, the explanations given by the physiologist on the subject were mostly based upon principles purely physical or chemical in their nature, making the nerve-fibre play the part of a simple, homogeneous organic wire without structure. The question, therefore, whether the medullary sheath, with its cylindro-conical segments, the annular constrictions of Ranvier in the external sheath, or the granular fibrillæ of the axis-cylinder, were but the products of a fanciful freak of nature, may justly be raised. Or, could it be that the compound anatomical structure of the axis-cylinder conducted nerve-force in the same manner as a homogeneous copper-wire conducts electricity? These questions must be answered, before a satisfactory theory on the production and conduction of nerve-force can ever be established.

For my part, I have always held the view that a difference of structure necessarily causes a difference of function: for, if it

were otherwise, differentiation of structure in organized beings would hardly take place. Therefore, it may be safely presumed that the structure of a tissue is always determined by adapting itself to the function of the organ of which it forms a part. For this reason, I shall endeavor in the following pages to direct the attention to those anatomical facts, which, as yet, have not been brought into harmony with the theories existing on the mode of production and conduction of nerve-force. But, as my time does not allow me to treat the subject to its full extent, I shall for the present confine my remarks and demonstrations to the so-called double-contoured nerve-fibres, of which the peripheral nerves are chiefly composed.

A double bordered nerve-fibre consists of three principal elements, viz.: the axis-cylinder; the nerve-medulla, or medullary sheath; and the external sheath, or tubular membrane, also known as the sheath of Schwann. The relative position of these elements is such, that the axis-cylinder, which forms the axis of the fibre, is surrounded by the nerve-medulla, and this, again, by the external sheath. When microscopically examined in serum, —while still in connection with the living animal, or, when removed from one freshly killed,—the double-bordered nerve-fibre is distinguished, as its name indicates, by well defined double-borders, while the part between the inner of these borders, forming the greater portion of the nerve-fibre, appears somewhat opaque, and exhibits a peculiar fatty lustre, which is owing to the refractive properties of the nerve-medulla.

In tracing one of these nerve-fibres throughout its length, it will be found that it is apparently divided into separate segments by a number of deep constrictions, the normality and true nature of which were first recognized by Ranvier a distinguished French histologist. This appearance of segmentation is due to the interruptions in the nerve-medulla, leaving the axis-cylinder, at the points of interruption, only covered by the external sheath, which, in order to reach the latter, becomes constricted at these points. The constrictions thus formed by this sheath are known as the "annular constrictions" (*étranglements annulaires*) of Ranvier (fig. 1, *d*). But, in examining a little more closely the individual segments formed by this singular interruption of the nerve medulla, it will be found that they themselves are subdivided by a number of deep incisures, observed in the medul-

lary sheath and passing obliquely from the inner surface of the external sheath to the axis-cylinder (fig. 1, *e*). These incisures, or indentations, are the same; to the existence and regularity of which, a number of years ago, I directed the attention of histologists, though Stilling, the great pioneer in the histology of the nervous system, had observed and mentioned them before me.[1] The segments of the medullary sheath, formed by the incisures, have been termed by Ranvier the "cylindro-conical segments;" they have of late years been the subject of much speculation and discussion, though their true anatomical nature, which I shall treat directly, seems to have been, as yet, not properly understood. The incisures, which in truth only represent the vacant spaces between each two of these segments, are not directed in a regular order toward one or the other extremity of Ranvier's segments, but, on the contrary, are arranged irregularly. Thus, in many places, where, in this manner, the narrow parts of two cylindro-conical segments meet each other, they are surrounded by a segment in the form of a ring, or true hollow cylinder (see fig. 1, *f*).

In subjecting now these elements composing the double-bordered nerve-fibre to a special consideration, we shall begin with the axis-cylinder which represents the *true* nerve-fibre. Formerly, when the nerve-fibre under discussion was still supposed to consist of a simple membranous tube filled up with a homogeneous nerve-medulla, the axis-cylinder was regarded as the axial part of this substance, remaining unaltered after the coagulation of its outer portion. In the course of time, however, in spite of the high authorities, who, without substantial reasons, most tenaciously defended this erroneous view, the axis-cylinder gained its proper position as a pre-formed, integral element of the nerve-fibre, representing, as already mentioned, its most essential part. But like the whole nerve-fibre, the axis-cylinder, also, was for a long time looked upon as homogeneous in its anatomical composition, until Max Schultze discovered, about 1867, that the processes of the ganglion-cells, as well as the axis-cylinders derived from them, were composed of fine, *smooth* fibrillæ, in the interspaces of which a number of minute dark granules were distributed. Finally, without a previous knowledge of this discovery, and not quite two years

[1] Stilling. "Ueber den feineren Bau der Nerven-primitivfaser und der Nervenzelle." 1856.

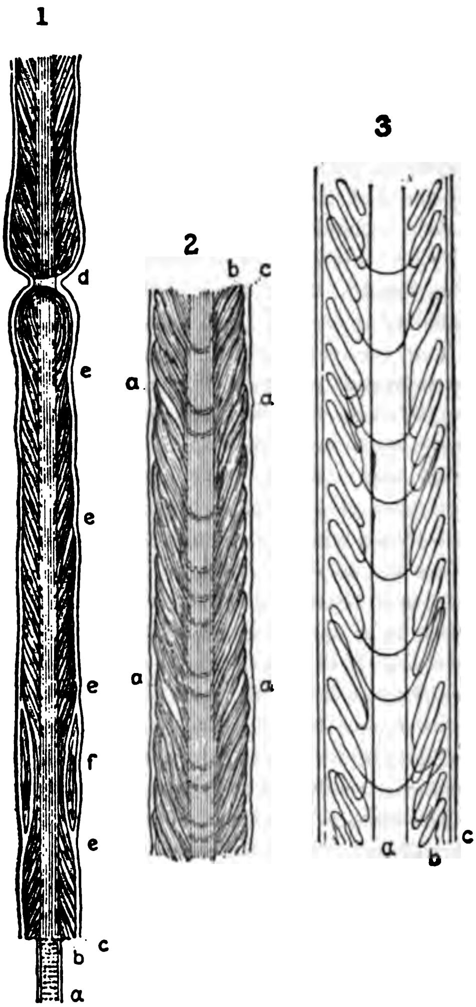

FIG. 1. Diagramatic representation of a double-bordered nerve-fibre, treated with a solution of osmic acid; *a*, axis-cylinder; *b*, medullary sheath; *c*, external sheath; *d*, annular constriction of Ranvier; *e*, incisures; *f*, cylindro-annular segment.

FIG. 2. Diagramatic representation of a double-bordered nerve-fibre (osmic acid preparation) highly magnified and showing the funnel-shaped subsegments, as well as the fibrillar arches passing from one side of the fibre to the other; *a*, incisures; *b*, fibrillar loops; *c*, external sheath.

FIG. 3. Schematic diagram illustrating the probable arrangement of the fibrillæ; *a*, axis-cylinder; *b*, fibrillar loops; *c*, external sheath.

terward, I discovered myself the true anatomical composition of e ganglion-cell processes and their respective axis-cylinders, ›nsisting of *fibrillæ representing rows of minute granules united one another by an intermediate substance;* in other words, *granar fibrillæ* (fig. 1, *a*). The correctness of this observation I vered by my investigations upon the development of the nervous ssues of the human embryo, in which I found the whole nerve ›nsisting of distinct rows of still ununited elementary granules, hich, in the course of the development, are formed into fibrils by lhering to one another. The axis-cylinder in the fully formed rve-fibre, therefore, consists, in proportion to its diameter, a greater, or smaller, number of granular fibrillæ, held together an interfibrillar substance, and surrounded by a sheath, which, ɔugh distinguished by a double contour, is very likely identical th the inter-fibrillar substance. When the axis-cylinder apɔaches its termination at the periphery, it divides successively ;o the individual fibrillæ, of which it was originally composed. As regards the medullary sheath of the double-bordered nervere, I will simply mention that in my paper "On the Construc›n of the Double-bordered Nerve-fibre," published May, 1874, the "London Monthly Microscopical Journal," I also minutely scribed the complicated anatomical composition of the nerveɘdulla, as consisting of two parts, or layers, the inner one which, surrounding directly the axis-cylinder, represented a ıely granular, amorphous semi-liquid substance, while the outer owed a structure composed of very delicate and smooth fibrils, ranged, in the fresh unaltered nerve-fibre, parallel and very ɔse to each other. I furthermore stated that these fibrils, on ac›unt of their interspaces being filled by the semi-liquid part, ›uld not be well detected in the fresh fibre, but that with the adtion of water, this liquid, penetrating through the external sheath, ɔuld dissolve the connecting element, and render the fibrillæ of .e nerve-medulla in the interior of the nerve-fibre very distinct the form of wavy or arched bundles. In the same form they 'e also observed to emerge from the open ends of the fibres, or, the form of a so-called hernia, through the orifice produced by small rupture in the external sheath.

In the above mentioned paper, at the time I directed the atntion to the incisures of the medullary sheath, the idea of the ontaneous coagulation of the nerve-medulla, and the inclina-

tion to explain by this process all the phenomena observed in this substance, still prevailed in the minds of the leading European histologists; and, regarding, at that time, the views of these authorities with a certain amount of reverence, though I was surprised at the regular order in which these incisures appeared, I really dared not form a strictly independent opinion of their signification. Thus, I happened to consider them as folds in the external sheath and nerve-medulla. Another reason of my failing to distinguish these segments as fully as I do to-day was, because my examinations were confined to the fresh nerve-fibre, or to fibres kept for one or two days in a very weak solution of chromic acid; for osmic acid, the most valuable re-agent to render the incisures distinct, was then beyond my reach.

The examinations, which I have since made of this subject, not only confirm the statements of other observers as to the existence of the cylindro-conical segments, but will, moreover, throw some additional light upon their true anatomical structure. Convinced, from my former studies, of the fibrillar nature of the normal nerve-medulla, I also endeavored to demonstrate its fibrillæ in nerve-fibres treated with weaker or stronger solutions of osmic acid. For this purpose I prepared and examined, from time to time, the fibres of a considerable number of nerves, or nervous fasciculi, of man and different animals, of which the former offers the most advantages for the investigation.

The results of these investigations corroborated my former statements as to the fine fibrillæ forming a part of the medullary sheath. The only error to be found in these statements—which was solely due to the examinations having been chiefly made on fresh nerve-fibres, or such as were treated with water, or with very weak solutions of chromic acid—relates to the particular arrangement of these fibrillæ within the nerve-fibre. For, though I observed and described their loop-like arrangement within the fresh fibre, or when escaping from its open ends,—such as the accompanying figures 2 and 3 will show,—I erroneously interpreted these forms as being produced by the action of water entering the nerve-fibre through the external sheath.

As a minute description of the true arrangement of these fibrillæ, and of the particular method of examination by which they may be demonstrated, would extend this paper beyond its proper limits, I shall, for the present, limit my remarks to the more prominent points

concerned, leaving the details to form the subject of another paper, purely histological in its nature. A few remarks concerning the action of the osmic acid solutions upon the nerves in different conditions, however, may serve to elucidate the subject more fully. When a perfectly fresh nerve has been left in a one per cent. solution of osmic acid for several hours, or is dissected in this solution, as Ranvier particularly recommends, the cylindro-conical segments will be found upon microscopical examination as they are generally described; that is, in the form of hollow cones in which no structure can be detected, for the reason, that the reagent firmly coagulates the entire segment, preventing the fibrillæ, of which it is composed, from separating as they are observed to do when acted upon by water, or by slight decomposition. If, however, the nerve is taken from the body of a man, or an animal, a few hours after death, a time when decomposition, if ever so slight, has commenced, a slight separation of the fibrillæ from one another will have taken place without a disturbance of their normal arrangement in the cylindro-conical segment, and their relative position will become fixed by the subsequent action of the osmic acid. The same object may be obtained by leaving fresh nerves, or their fasciculi, in a weaker solution of osmic acid for a longer time, in which case the water of the solution has a chance to slightly separate the fibrillæ, before they are fixed by the action of the acid.

In such preparations, it will be found that the cylindro-conical segments, as they are observed in the firmly coagulated nerve-medulla of a perfectly fresh fibre, consist in reality of a number of subsegments, representing a system of loops formed by the fibrillæ in the manner represented in the diagrams, figs. 2 and 3. Each subsegment resembles in form a hollow cone, or a funnel, placed with its narrow end, or apex, into the base, or trumpet-like opening, of the following segment, and receiving on the other side its preceding neighbor. While the margins of the bases of these fibrillar funnels are in contact with the inner surface of the external sheath, the margins of their narrow extremities embrace the axis-cylinder. Judging from the length of the fibrillar bundles observed to emerge from the open ends of a fresh nerve fibre, the fibrillæ, forming the funnels, must be continuous throughout the whole length of the medullary sheath of one segment of Ranvier, and must be bent twice upon themselves in order to form a sub-

segment, or funnel: in other words, starting from the axis-cylinder they pass obliquely over the preceding segment and, after having embraced a portion of this, are bent to return to the axis-cylinder, reaching it at a point a little farther from that whence they started (fig. 3). From this point, they are again bent to pass over the segment just formed, and, being bent once more in the form of loops, return as before to the axis-cylinder.

From the preceding description of the nature of the funnel-shaped segments of the medullary sheath, it might be inferred that this substance solely consisted of the fibrillary loops. This, however, is not the case; for another important body enters into the anatomical composition of the nerve-medulla in the form of that semi-liquid substance already mentioned, which fills every space, not occupied by the fibrillar loops, between the axis cylinder and the external sheath. It is this substance which, in truth, represents the medulla of the nerve-fibre, and to which the refractive properties, and the fatty nature—indicated by the color following the action of osmic acid—must be assigned.

In the unaltered nerve-fibre, the subsegments of the medullary sheath closely touch each other, for which reason the incisures between them cannot be readily detected; while, on the other hand, those incisures which mark the boundaries of the larger cylindro-conical segments, are easily distinguished by representing larger interspaces. Each original cylindro-conical segment, therefore, represents a group of subsegments.

The above sketch of the fibrillæ forming the funnel-shaped sub-segments of the nerve-medulla relates, as may have been noticed, only to their longitudinal course along the axis-cylinder, while their arrangement and mutual relationship around this body still remain to be mentioned. To ascertain this arrangement forms the most difficult part of the whole investigation into the structure of the medullary sheath; to discuss it minutely would oblige me to pass the limits of this paper, especially as there are some points concerned, which I would like to elucidate more fully to my mind by further investigation, before forming a definite opinion. I shall, therefore, only mention that the fibrillar loops of each individual funnel do not appear to be arranged parallelly, but to overlap each other slightly. Such an imbricated arrangement is particularly observed in stained, thin horizontal sections of a nerve, when examined in glycerine by oblique illumination. It

appears to me, furthermore, that the loops do not extend entirely around the axis-cylinder, but leave, in an opposite direction, two small intervals along the longitudinal course of this body, dividing each funnel into halves. This division, however, is not complete, for a number of single fibrillæ are observed to pass, in the form of arches, from one side of the funnel-shaped segments to the other (figs. 2 and 3).

From the above description, based upon my more recent observations, it will then be seen that the medullary sheath of each of Ranvier's segments represents, in reality, a separate system of continuous fibrillar loops, invaginating one another, and reaching from one annular constriction to the other. In nerve-fibres treated too rigorously with osmic acid, the coagulation of the nerve-medulla is carried to such an extent as to render it brittle, as is indicated by the fractures observed upon it. It is thus that, during the manipulation of separating the nerve-fibres, the cylindro-conical segments will break at their narrow extremities, a phenomenon which has given rise to the idea that they represented ununited portions of the nerve-medulla. The incorrectness of this supposition is easily proved by observing, as before remarked, the length of the loops issuing from the open end of a fresh nerve-fibre, and comparing it with that of a single cylindro-conical segment.

The continuity of these segments may be easily observed upon the finer nerve-fibres, met with in every fascicle of a peripheral nerve. If the nerve-fibres of man — which on the whole show their structure more distinctly than those of the smaller vertebrated animals — are carefully separated by means of very finely pointed needles, it will be observed that the fibres of which the fasciculus consists greatly differ in their diameters. Aside from the larger ones, corresponding in their structure to the description above given, a number of others, much smaller in diameter, are met with, which, in place of the cylindro-conical segments, present only a row of ovoid or oblong swellings, the so-called varicosities. In the finest nerve-fibres, these varicosities, though connected with one another by a thin layer of nerve-medulla extending over the axis-cylinder in their intervals, appear very distinct, but present no trace of invagination, or incision. In examining, however, the nerve-fibres of a slightly larger diameter, the first traces of the incisures are met with, increasing in depth with the diameter of the fibre, until finally, in the largest variety, all the details of their structure are

distinctly observed, as above described. It appears, therefore, that the development of the cylindro-conical segments is proportionate to the diameter of the fibre. The correctness of this assertion will be found corroborated by studying the development of the nerve-medulla in the nerves of the human embryo, or fœtus. Accordingly, in order to test the truth of my former statements, I repeated, some time ago, my investigations into the development of the nervous tissues, and found that the nerve-medulla first appears upon the fibrillar axis-cylinder in the form of oval varicosities, which are separated from one another by considerable intervals. These intervals, however, become gradually reduced in length by the formation of new varicosities, and finally disappear by the latter extending, in the form of a thin layer, over the still uncovered portions of the axis-cylinder, to form, in uniting with each other, a segment of Ranvier. At this stage of development, we have a picture of one of the finer nerve-fibres in the adult nerve. As in the latter, in the embryonic nerve-fibres, also, the annular constrictions of Ranvier are not fully developed, but only recognizable by the absence of nerve-medulla. In the nerves of the human fœtus of seven months, the incisures, indicating the invagination of the nerve-medulla, may be already observed in some of the larger nerve-fibres; though, in many others, the cylindro-conical segments appear unconnected, and their extremities almost rectangular in form, that is, the incisures at right angles to the long axis of the nerve-fibre. The annular constrictions are here only distinguished by a broader light space, due to the absence of the nerve-medulla. These observations show, that some similarity exists between the undeveloped nerve-fibres of the human fœtus and the finer variety of fibres in the adult nerve, from which the conclusion may be drawn, that the varicosities of the latter do not represent artificial products, but must be regarded as preëxisting parts of the nerve-fibres, indicating simply an arrest of higher development.

As regards the length of the segments of Ranvier in the peripheral nerve-fibre of man, I may state, that, like the development of the cylindro-conical segments, it is also proportionate to the diameter of the fibre. Thus, while in the larger fibres it ranges from $\frac{80}{100}$ to $\frac{95}{100}$ mm., it only amounts, in the finer ones, from $\frac{45}{100}$ to $\frac{50}{100}$ mm.

Before dismissing the structure of the double-bordered nerve-fibre, another phenomenon, which it presents when left for a short

time in a weak solution of nitrate of silver, should be mentioned. I refer to the so-called "biconical swellings" (*renflement biconique*) of Ranvier, which appear in the annular constrictions after the treatment with this reagent, and are placed at right angles with the axis-cylinders, forming with the latter the known crosses. It is sufficiently known that certain parts of a tissue, as, for instance, the intercellular substance, or cement, which glues together the cells of an epithelium, possess the property, not only of absorbing, but also of decomposing under the influence of sunlight the above mentioned salt, giving rise to a deposition of the oxide of silver into their substance. Accordingly, when double-bordered nerve-fibres are treated with a solution of this salt, the latter first penetrates into the nerve-fibre at the annular constrictions, where in order to get into the interior, it has only to pass through the external sheath; and it is thus, that the axis-cylinder generally absorbs for a short distance the salt, and after decomposing it by exposure to light, appears colored brown, and besides, exhibits those transverse striæ, first observed by Fromann. But, at the same time that, in this manner, the axis-cylinder assumes, according to the amount of silver-oxide deposited, a lighter or deeper brown color, the biconical swelling of Ranvier, also, makes its appearance, forming with the axis-cylinder the known "cross." The explanation which Ranvier has given to this phenomenon is: that the biconical ring, or swelling, is identical in composition with the cement-substance of the epithelial cells, and that its function is to glue together the two adjoining segments, which he regards as the cells of which the nerve-fibre was originally formed. Anxious to find out the true nature of this biconical swelling, I prepared, some time ago, and also recently, a considerable number of specimens of nerves of man and different animals, such as the rabbit, cat, mouse, frog, etc., and subjected them from time to time to very close microscopical examinations, resulting in a corroboration of the statements of Ranvier, as far as the appearance of the crosses is concerned. But, as regards the nature and function of the biconical ring, I cannot but oppose the view of this observer, for the reason that this ring, or swelling, cannot be detected by the most scrutinous examination in nerve-fibres treated with osmic acid, or other reagents, which would be the case, if it were preëxistent to the nitrate of silver treatment. Even in the silver preparations, it does not always appear in the same form, but differs,

both in form and size, in different constrictions; in some, even, it is observed in the form of an unshapely mass of dark granules. There are other reasons against its preëxistence, which, however, have to be passed over for the present, and postponed to another occasion, when I shall be able to discuss the subject more fully. I, therefore, confine my remarks to saying, that, after careful examinations, I cannot but regard these biconical swellings as artificial deposits of the oxide of silver, particularly proved by the fact that the metal is not only deposited in the constrictions around the axis-cylinder, but moreover, very frequently extends upon the internal surface of the external sheath, forming the extremity of the segments.

As regards the theory of the segments of Ranvier representing the original cells of which the nerve-fibre was formed, I must likewise reject it, being fully convinced from my numerous researches into the development of the nervous tissues, that the nerve-fibres are not formed from cells.

Having in the preceding pages briefly alluded to the principal electrical phenomena of the nerves, and described the complicated structure of the nerve-fibres, we are now ready to compare the existing theories on the production and conduction of nerve-force with the facts stated above. In making this comparison, however, I may say, that my object, at present, is not to offer a better theory than those already existing, but merely to point at the want of correspondence between the latter and the anatomical structure of the nerves. In all of these theories on the subject, as I have mentioned once before, the nerve-fibre figures as a homogeneous thread, or, as a tube filled with a homogeneous substance, similar to a conducting copper-wire, surrounded by its silk-insulators. The medullary sheath, with its interruptions at the annular constrictions of Ranvier, has hardly ever been taken into account. As I have remarked before, this part of the nerve-fibre with its complicated structure would not exist, if it were not essential to the proper performance of the function of these fibres. Nor would the annular constrictions of Ranvier exist, if they were not conditioned by the interruptions present in the nerve-medulla. In considering these interruptions in the medullary sheath a little more closely, it becomes obvious that the nervous current, passing through the axis-cylinder, must become modified while traversing the constrictions, where the external sheath forms the sole covering

of the anatomical conducting element, the axis-cylinder. It is, at present, difficult to determine the exact nature of this modification of the current, though it is not at all improbable that a variation in its strength takes place at the point of constriction, making it resemble the interrupted current of an electric battery which, as we know, calls forth tetanic muscular contractions, when applied to the exposed nerve of a frog's limb. This supposition may be better understood by inquiring a little more closely into the probable function of the medullary sheath.

The idea has at different times prevailed, that the relationship of this sheath to the axis-cylinder was similar to that existing between the silk-covering and the copper-wire of a galvanic battery; in other words, that it performed the function of an insulator to the nervous current passing through the axis-cylinder; and the probability of this supposition could, for well founded reasons, not be disputed so long as the cylindro-conical segments were either unknown, or even, as now, regarded as homogeneous and structureless. In the latter case, variations in the nervous current might have been supposed to occur, also, at the places of incision. Since I have shown, however, that the cylindro-conical segments represent a system of fibrillar loops, embedded in the semi-fluid part of the nerve-medulla, this view is rendered untenable, for it can hardly be supposed that these loops are essential to a simple process of insulation. Before attempting, however, to construct another hypothesis, we should first ascertain whether there exists an intimate connection between the fibrillar loops of the nerve-medulla and the axis-cylinder.

I have stated above that the loops, after surrounding the preceding funnel-shaped segments, return to the axis-cylinder which they also surround, but omitted to say, whether there existed any connection between this body and the fibrillæ of the loops. As far as my observations allow me to judge, there exists no connection, for the reason that, if this were the case, the masses of the fibrillar loops, issuing from the open ends of fresh nerve-fibres, would not appear as long and voluminous as they are observed to be. In such instances, the fibrillar arches, formed by the unwinding, or unravelling, of the loops when emerging from the ends of the fibres, not only greatly exceed the double length of a cylindro-conical segment, but, moreover, many individual loops, representing these segments, are *almost always observed* to escape from the

nerve-fibres. Thus far, therefore, we may presume, that the fibrillæ throughout an entire segment of Ranvier are not connected with the axis-cylinder. But, the question as to the manner, in which they commence and terminate within these segments, bounded by the constrictions in the external sheath, still remains to be answered. I am not prepared to answer this question definitely, for they may either commence and terminate by free extremities, or, they may not terminate at all by forming in each segment, so to say, a closed system of fine organic wires immersed in the semi-liquid substance, as represented in the schematic diagram, fig. 3. Such an arrangement appears to me more probable than the one first alluded to. Though I am far from drawing any conclusions from these suppositions, before they are more substantiated by direct microscopical observation, I cannot entirely dismiss the idea that these fibrillar systems of the medullary sheath of the nerve-fibre may stand, in one way or the other, in some relation to the nervous current passing through the axis-cylinder. If the fibrillæ themselves represent nervous elements, it would not be going too far to infer that they may be, also, the carriers of nervous currents, the special function of which, however, would depend upon their particular arrangement. If arranged in the form of closed systems, as I suspect, the nerve-force, produced by the molecular changes accompanying the process of nutrition, might circulate through these systems in the form of circuits, increasing the main nervous current in strength by way of induction.

In extending our remarks now to the particular mode of production and conduction of the main nervous current passing through the axis-cylinder, we find, as in the case of the medullary sheath, that, even, in the most recent theories, the structure of the axis-cylinder, such as I described it nearly eight years ago, has not been taken into account, the theories being only adaptable to smooth, homogenous nervous fibrillæ. But, the axis-cylinder, as I have demonstrated above, does not consist of smooth fibrillæ; on the contrary, its fibrillæ are of a compound nature, that is, made up of two different elements, represented by very minute elementary granules arranged in regular rows, and of another substance by which, at a later embryonal period, these granules are cemented to one another. That there exists a difference in the chemical composition of these elements is easily proved by the well known striæ of Fromann which make their appearance upon the axis-

ylinder by the action of nitrate of silver. In this instance, he cement-substance, holding together the elementary granules, ppears of a much darker color than the nodules of the fibrillæ hich represent the original granules, indicating that the former ossesses a greater power of decomposing the silver salt than the tter; hence, both elements must chemically differ from one an- her.

While, however, this heterogeneous composition of the nervous rillæ, demonstrated by microscopical examination, must be re- irded as a settled fact, we should not forget, that a further differ- itiation of structure may also exist in these fibrillæ, which the icroscope is unable to show. In the muscular fibre, we know iat both the sarcous elements, as well as their intermediate sub- ance, are individually not homogeneous throughout, but each is mposed of subdivisions, or disks; and, it is not at all impossi- le that a similar arrangement may exist in the nervous fibrillæ, o delicate, however, to be detected by microscopical examination. evertheless, whether such a differentiation exists, or not, in the ervous fibrillæ, the existence of two elements, that is, the gran- les and the intermediate substance already known, would suffice show that the passage of the nervous current through the axis- ylinder is not to be compared to the electrical current passing long the homogeneous metallic wire of a battery, but rather to he current of a voltaic pile, consisting of heterogeneous, or un- ike, elements.

We may further infer that the nervous current cannot be strictly ompared with that of static or dynamic electricity which, after eing produced, passes unaltered through the conducting wire, its trength solely depending upon the amount of electricity generated y the electrical machine, or in the galvanic battery. The battery n which the nervous current originates remains in action during he whole life of the animal, commencing with the stimulus that ives rise to the development of the egg, and ending when, from ny cause, the life of the animal becomes extinct. Neither does his current solely depend for its production upon a particular entral apparatus, but is, very probably, also generated in the con- ucting elements, the nerve-fibres themselves. During life, it is onstantly fed by the forces liberated by the molecular changes aking place constantly in the process of nutrition of the various issues; and any disturbance of this process, particularly in the

nervous tissues themselves, necessarily causes corresponding changes in the strength and character of the current.

In referring once more to the mode of production of the nervous current, I may say that the view of Hermann, according to which the liberated forces are chemical in their nature, appears the most plausible. That these forces are called forth by chemical action appears, moreover, indicated by the variations in the rapidity of nervous conduction, observed not only after the introduction of intoxicating substances into the blood, such as alcohol, opium, etc., but also when the nervous tissues are affected by disease.

The above remarks on the production and conduction of nerve-force must be considered as mere fragments of a subject, which, by its unlimited extent, has always fascinated the mind of the philosopher. But, as the limits of this paper are already passed, I must, for the present, close the discussion with the prospect of continuing it on some other occasion.

Is Man the highest Animal? Note by Charles Sedgwick Minot, of Roslindale, Boston, Mass.

The measure of zoological rank is the specialization exhibited by all the organs, taken collectively. Specialization may be exaggerated in one or several organs, without the animal therefore attaining as a whole a high rank. This is the case in man. The measure of specialization is afforded by embryology, which shows in earlier stages the simplicity and uniformity of structure, which in later stages is replaced by complexity. The human body preserves several important embryonic features. In man we find three series of high differentiations, namely: —in the brain, in the changes induced by or accompanying the upright position, and third in the opposibility of the thumbs to the other digits. These are the principal, though of course not strictly the only, characteristics of man, which show that he is more specialized than any other animal. In other respects he shows a still more striking inferiority. It is of course a familiar observation that his senses are less acute than those of many animals, — he has neither the keen vision of the falcon, nor the deli-

ate scent of the dog. He is equally inferior in many structural atures. His teeth are of a low mammalian type, as is shown oth by his dental formula, and by the presence of cusps upon the rowns of the teeth, a peculiarity of the lower mammalia, entirely st in the horse, the elephant, and many other "brutes." His mbs show a similar inferiority since they are little modified, preerving even the full number of five digits, and in respect of these embers man stands therefore very low, lower than the cow and the ig. He plants the whole sole of his foot upon the ground, yet none xcept the lower mammalia, together with man and his immediate ongeners are plantigrade. So too with his stomach, which is so mple as compared with that of a ruminant, and indeed is of about e same grade as that of the carnivora. It makes however a still ore forcible impression to learn that the human face, which we adire when withdrawn under a high intellectual forehead, is perhaps e most remarkable of all the indices that point out man's inferirity. In the mammalian embryo the face is formed under the fore rain or cerebral hemispheres. In our faces the fœtal disposition permanently retained, with changes, which when greatest are till inconsiderable. In quadrupeds the facial region acquires a rominent development leading to the specialization of the jaws nd surrounding parts, which brings the face to a condition much igher than that of the fœtus. Hence the projecting snout is a igher structure, than the retreating human face. These facts have ng been familiar to anatomists, but I am not aware that the inriority of the human to the brute countenance has heretofore een considered a scientific conclusion by any one. Yet that inriority is incontrovertible and almost self-evident.

The preceding statements render it clear to the reason, that an is not in all respects the highest animal — and that it is a silly rejudice of arrogant ignorance, that assumes that the specializaon of the brain marks man as above all animals in the zoological ystem. It does give him a supremacy by his greater power of selfaintenance in the struggle of the world, but that has nothing hatsoever to do with his morphological rank. There is nothing morphology that anywise justifies assigning, as is actually done, n almost infinitely greater systematic value to the specialization f the brain and a specialization of the limbs, stomach, teeth, face, tc.,— hence it is impossible to call man even the highest mammal.

It is also doubtful whether mammals would be regarded as the highest class of the animal kingdom, were they not our nearest relatives. Let us beware of claiming to be the head of organic creation, since the carnivora and ungulata are in many respects higher than we. I believe that it is just as unscientific to call any one animal species the highest, as to pitch upon any one plant to stand at the head of the vegetable kingdom.

On a Mesal Cusp of the Deciduous Mandibular Canine of the Cat, Felis domestica. By Burt G. Wilder, of Ithaca, N. Y.

In all kittens examined by me, and in a young African lion, the mesal aspect of the deciduous mandibular canine tooth presents a small, but perfectly distinct, *cusp* or *tubercle*.

The cusp may be represented on the maxillary canine by the slight "shoulder," but it does not appear on the permanent canines of either jaw.

Comparison with the series of incisor teeth leads to the suggestion that the larger part of the crown of the canine is simply a much developed intermediate cusp. The flanking cusps would be represented by the newly observed tubercle, and by the slight shoulder upon the lateral aspect of the tooth.

Fossil forms and the young of other Felidæ should be examined with reference to the presence of the mesal cusp.

It is probable that some ancient or more generalized feline will be found to have deciduous, and perhaps permanent, canines with a less disproportion between the intermediate cusp and the other two.

Should this anticipation be realized, the non-appearance of the mesal cusp in the permanent canine of the existing specialized species, would be in accordance with the general idea as to the manifestation of ancestral features in the young rather than in the adult.

So far as I am aware, the mesal cusp has not been observed heretofore. Its discovery was first announced by me at a meeting of the Cornell Philosophical Society, Jan. 15, 1881.

Bopyrus manhattensis from the gill cavity of Palæmonetes vulgaris Stimpson. By Carl F. Gissler, of Brooklyn, N. Y.

[Abstract.[1]]

In May 1880 and June 1881 I found about ten per cent. of the common prawn, *Palæmonetes vulgaris*, infected with a species of Bopyrus which I provisionally call *B. manhattensis*. It is probably the same species mentioned by Professor Jos. Leidy as occurring near Atlantic City, N. J., on the common prawn (Proceedings Acad. Nat. Sc., 1879).

The *female* of our Bopyrus averages in size from 3.50^{mm} to 4.50^{mm} in length and 3^{mm} to 4^{mm} in width. Its ventral side is invariably turned toward the carapace of the prawn and its marsupium or breeding cavity is usually filled with minute yellowish eggs of a spheric form. The marsupium is formed by the prolonged lamellous margins of the thoracic segments. The body of the *female* is of a whitish color, and, as in all members of this family, is somewhat distorted and unsymmetric, one side having narrower segments than the other, and is therefore of triangular shape. The absence of eyes as well as antennæ proper, in the female, is the result of parasitic life and presents examples of degeneration.

The head consists of two unequal fleshy lobes. The dorsal lobe is triangular and somewhat unsymmetrically placed; the ventral is of subquadrate shape, anterior angles produced, posterior angles rounded with the middle of its posterior part prolonged, rounded.

A pair of maxillipeds is inserted at the sides of the ventral cephalic lobe. They constitute a flat, roundish terminal piece, the palpus, with nine marginal hyaline tentacles; the basal joint is connate with and obliquely inserted into the median lobe. A number of muscle-nerves (nerve and muscle together) run to the tip of the basal joint, some of which enter the palpus, and others distribute themselves along the tip of the former. A beautiful dendritic arrangement of black pigment is found near the base of the palpus. From underneath the body of the ventral cephalic lobe arise a number of narrow, ligulate, gill-like appendages which in the living animal have a constant rapid paddling motion. Viewed under higher microscopic power they exhibit a granular structure

[1] This paper is given in full with illustrations in the American Naturalist for Jan. 1882.

with longitudinal hyaline and apparently lacunary canals. If it were not for their abnormal position near the anterior part of the body, and their structure, I should regard them as gills, and to be consistent, I am obliged to regard them as paddling organs for the purpose of aërating the eggs or embryos contained in the marsupium.

The seven pairs of feet are curved forward and downward and terminate in an indistinct hook-like knob. The black pigment is very irregularly distributed in the feet, some feet are yellowish, some are slightly colored, and others are nearly all black. Some individuals have all the feet uncolored. The pigment appears to be centrally located and is better noticed in living than in alcoholic specimens.

The thoracic segments have, as probably in all the Bopyridæ, their margins prolonged into more or less lanceolate darkened lamellæ. To these lamellæ the feet are attached. The lamellæ attached to the first pair are small, oval lobes having the entire margin fringed with hyaline tentacles; the second and third pair of feet have very broad lamellæ, with sub-ovate tips directed forward, and with their anterior margins fringed; the fourth, fifth and sixth pairs of feet have lamellæ which are short, broad, and irregularly triangular pieces; the seventh lamella is very long, narrow and lanceolate.

The marsupium is an open roundish cavity, surrounded by the above mentioned lamellæ, and is covered by the carapace of the prawn.

The abdomen is laterally deeply segmented and is provided on its middle with roundish appendages overlapping each other. I have closely observed the living females and doubt very much if these abdominal appendages have the functions of gills. They consist of a larger thick fleshy lobe, and a smaller still thicker roundish piece. They are the degenerate, post-abdominal legs, characteristic of the order Isopoda. Usually four, but sometimes six, pairs of the thoracic epimera are black.

The *male* averages about 1^{mm} in length and 0.25^{mm} in width. Head with a pair of lateral dark eye-spots. Head and seven thoracic segments black, the pigment exhibiting, beside the ordinary form, a pretty stellar arrangement.

Anterior angles of thoracic segments oblique. Abdominal segments four, pale, their margins perfectly round, gradually becom-

ing narrower toward the terminal median piece, which is minute, and, on treating with acetic acid, is seen to consist of two lobes. Eight pairs of feet with powerful claws. Antennæ apparently two-jointed, first joint club-shaped with five bacilli on its tip, second joint much narrower, about one-quarter as long as the first, with six bacilli at its tip.

The living males were removed from under the ventral lobes of the abdomen of the females (one male only in each female) and placed on paper wet with salt water, where they slowly walked sidewise. The females moved their legs to and fro and contracted their abdomen only on touching the ventral appendages. They kept rapidly paddling with their gill-like cephalic appendages as already mentioned. I presume that both sexes get their necessary aëration through the motions of the gills of the prawn and, as the embryos are laterally covered by the marsupial lobes of the female and exteriorly by the carapace of the prawn, the additional fanning of the female cephalic appendages is intended for aëration of the embryos.

From three hundred to four hundred eggs are usually found in the marsupium. The eggs measure 0.2^{mm} in diameter.

On the disposition of Color-Markings of Domestic Animals.

By Wm. H. Brewer,[1] of New Haven, Conn.

For some years I have been making and carefully recording observations on the color-markings of domestic animals and have made it the subject of two papers read before the Connecticut Academy of Sciences (April 19, 1876, "On the color-markings of Horses," and Sept. 17, 1879, on "Some facts about the color-markings of domestic animals"). Those papers have not been published further than in the most meagre and imperfect newspaper notices. The present paper covers the same ground and is offered here partly that I may have the suggestions and coöperation of other observers, and partly to publish facts which have had but a limited publication before. The tables of numerical results upon which some of the conclusions are based will be published at another time.

First. Many horses of otherwise solid colors, particularly bays, browns, and blacks, have what is called white feet, that is, with more or less white just above the hoof, the legs otherwise being black, or at least of a darker color than belongs to the neck and body of the animal. This marking usually consists of a belt of white hair extending entirely around the leg, varying in extent from a mere white ring just above the hoof, to a long stocking extending far up the leg and ending abruptly and sharply; more rarely the white constitutes a mere spot, and when thus restricted, it is oftenest on the hind side of the leg. The hoof may or may not share the white color, but is liable to be white if there is white hair immediately above it.

Observations made in several different parts of the country, and extending to several thousand foot-marked horses, *show that more of the white feet are on the left side than on the right.*

The left hind foot is the one most often marked, and the right fore foot the one least often, the order of frequency of white feet being the left hind, the right hind, the left fore, the right fore. When three feet are marked two of them are oftenest on the left side. When only the two feet on the same side are marked, they are most often the two left feet.

The relative frequency of each of the fifteen ways in which the

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white feet may be disposed, as well as the percentage of foot-marked animals of each color of horses, will be given at another time.

The hind feet are much oftener white than the fore (unlike the horse of nature, the horse of art has the fore feet white more frequently than the hind feet) and if one examines the cases where only the two hind feet are white, in a majority of cases the amount of white is the greatest on the left leg, the white extending farther up. This is probably true also where only the two fore feet are white; but this is such a rare marking that I cannot state the fact from actual observation.

Here let me say that some combinations of foot-markings are so rare that if owners of horses kept records of them they might sometimes be important data in the identification of lost or stolen horses. For example, a bay horse with only the right fore foot white, or one with the two fore feet white, the right one being white farthest up the leg, is so comparatively rare compared with the whole number of horses, or even of bay horses, that it would be an important factor in legal identification.

Second. Observations made on spotted horses show that a majority of them have more white on the left than on the right side. This shows itself in two ways. In the first place, if the amount of white is small, and if there is merely a white spot on the horse (other than on the face or just above the hoof), then such spot is oftenest on the left side. In the second place, if the animal is decidedly spotted ("Calico," or "Pinto"), then the area of white (so far as could be judged by the eye in the examples observed) is greatest on the left side in a majority of cases.

Formerly spotted horses were fashionable, as they still are among barbarous or semi-barbarous peoples, and indeed among people of our civilization in regions where horse-stealing is also fashionable, but spotted horses are now so unfashionable in the older states that it is not easy to find a sufficiently large number for extensive generalizations. So far as observed, however, the rule holds good, and I have not included in my figures those cases where several such horses seen together and originating on the same ranch might have a similarity of marking due to family heredity.

Third. Mules are rarely spotted, although such are occasionally seen, but I have never seen a foot-marked mule, and never had

but one reported to me, that is, a mule with a white foot or white feet. This applies to mules with solid colors; spotted mules sometimes have white legs and feet.

Fourth. As to horned cattle my data are much more scanty and also less satisfactory. In the first place they are not foot-marked as horses are, but if white occurs, it is in quite another fashion. On the legs it is usually in spots, blotches or patches, and such blotches or spots I think are oftenest on the front side of the leg usually not extending to the hoof, ill defined, and very rarely in a clean, well defined white ring or stocking, as we see so common with horses. Moreover, at agricultural fairs, where many breeds are exhibited, the numerical results of observations on spots are often vitiated because of the families or strains exhibited together and similarly marked by heredity. However, so far as my observations go, they point in the same direction, and I strongly suspect, that the same rule holds good with cattle as with horses, and that with them also white occurs more frequently and in greater quantity on the left side than on the right, although my observations are too few to prove it by large numerical data.

Fifth. The same may be said with dogs, but here the occurrence of white feet and their disposition have no value in such an investigation, because white feet are a "fancy point" which is bred to, in some common breeds. If the right and left are shown in dogs by color, I have not been able to verify it by numerical data, but it is strongly shown by the tail being carried on the left side, in the vast majority of cases. With some breeds, this has long been a character (a "point" as breeders say) and even in breeds where this is not a "point," it is usually true in fact. It is not true however, as has been sometimes stated, that dogs which carry their tails to the right, are more liable to be afflicted with rabies.

Sixth. With swine as with dogs, the number and disposition of white feet are of no significance in this connection, because with some breeds (as in the Berkshire) white feet constitute a "fancy point" bred to, and I have not been able to carry my observations to the relative areas of white on the two sides of spotted hogs in a sufficiently large number of cases to generalize from, but enough however to lead me to surmise that the rule holds good here too, and that swine have the most white on the left side.[2]

[2] Unlike that of the dog, the curl of the pig's tail is as often on one side as on the other, and indeed the organ is carried on either side according to the taste or fancy of the wearer.

Seventh. From the observations made on the disposition of colors on our spotted domestic animals, it seems to me probable that with each species, white occurs more frequently and in greater quantity on the left side.

And if so with domestic animals, why not with wild animals also? But here my means of observation have been far too restricted for generalization. The few specimens in menageries, the stuffed skins in museums, a very few spotted skins of sport-marked wild animals have been too few to generalize from, and yet that few has pointed in the same way. The only wild species of mammal partly white to which I have had access in any number is the skunk. As is well known, these vary greatly as to the amount and the pattern of the white markings, and this determines the relative value of the skins in the market. In the skins I have examined, the majority had the most white on the left side; the number however is too small (only about sixty) upon which to base generalizations.

As the result of a long continued investigation (one by no means finished, I hope), I strongly suspect that it is a law of nature that mammals have most white on the left side, and that adventitious or sportive markings of white are most liable to occur on that side; that as color is one of the characters most sensitive to modifying influences and consequently the first to vary if there is any cause of variation; that it is the first external indication which we have showing a difference between the right and left, a differentiation which culminates in the right-handedness of man.[3]

Eighth. As to the more immediate cause, that the left side is the weaker side early suggested itself, and white hair is to a certain extent, a sign of weakness, the hair of man, horses, and various animals whitens with age, and I think that usually the hair and whiskers of man and the hair of woman begin to be obviously gray on the left side first.

The relation of the color-markings of domestic animals to bilateral symmetry has been the subject of discussion in late years, and from time to time the statement has been made and reiterated in various ways and shapes that one rule holds with wild animals and quite another with domestic ones,— that whereas wild animals

[3] There are numerous statements floating about on the sea of newspaper literature relative to the right- or left-handedness of animals being indicated in this or that way: that horses step the right foot forward first, that elephants use their left tusk most, by preference, and other statements of a similar character, but so far as I have been able to observe, I have not found one of these to be borne out by investigation.

if marked at all are marked alike on the two sides, domestic animals are not.

My own conclusions are that there is no such difference of principle, that the actual differences observed are merely those of degree, and not of kind.

The disposition and kind of color-markings on wild animals are doubtless related to protection and ornament, both of which would apply to both sides alike, for if there is any reason why markings or dispositions of color on one side are either protective or ornamental, these reasons are equally strong for the opposite side, and a general bilateral symmetry of color follows as a necessity, although there is a continual tendency to vary towards irregular and unsymmetrical markings. But this symmetry is more apparent than real, more general in effect than special in detail. I have examined hundreds of skins of color-marked animals, tigers, leopards, cougars and other species of the cat family, zebras, in fact *all* the skins of marked animals to which I have had access for many years and I never find the bilateral symmetry absolute in the details. The markings of the two sides of the animal resemble each other in a general way, the general effect is the same, but when compared spot for spot, stripe by stripe, the agreement is less complete than one would be led to expect from theory, the individual marks vary in every character except the most general. This is still more obvious if we compare different animals (of the same species) with each other. This is true even of spotted serpents, from the little spotted snakes of our own country to the formidable reptiles of Brazil and Africa.

Wild animals are sometimes spotted by sportive markings. These make the creature conspicuous to its enemies, and being the reverse of protective, such spots are quickly eliminated. All who have been in the far west know the zeal with which even the human hunter goes for a spotted bear or buffalo, or other abnormally marked beast. Nature tolerates only a limited amount of variation, but the individuals of a species vary just as widely as the external conditions of safety and sexual attractiveness allow.

In domestication, any irregularity of color-marking becomes protective, facilitating recognition and identity, and thus is of value to the owner of the property. Irregularly disposed spots and markings have had a protective value among stock owners ever since the days when Jacob "made the white appear," and claimed

the "ringstreaked, speckled and spotted cattle" as his own, and doubtless much longer.

With our modern breeders, fashion largely decides what colors are to prevail and how they are to be distributed. Where any color-markings are breeders' "points," they are symmetrically disposed; the white feet of Newfoundland dogs and Berkshire pigs, the broad white belt on the "sheeted" breed of cattle, and other breeds symmetrically marked suggest themselves. In such breeds the markings, *if bred to* (which really means "artificial selection"), are as symmetrically and as regularly disposed as are the color-markings of wild animals, under the operation of "natural selection," more so than is the case with the skunk.

Where color-markings do not constitute breeders' points, they are then as irregularly disposed as are the sportive colorings of wild animals. The spotted bears and buffaloes (sports), and occasionally deer, are as irregularly marked as are the cows of our herds, or the calico horses seen in our streets. With wild animals, such sports are eliminated, as already explained. With horses, in countries where such markings are protective for establishing ownership, or where fashion or fancy creates a market, they are bred, and are then common; when unfashionable, calico horses are almost as rare as spotted bears.

Some breeds are irregularly spotted, like the Dutch ("Holstein") cattle and Poland-China swine. In such cases, the irregular markings become a "fancy point" of some value and are bred to, and in such cases spotted will be the prevailing color. But if fashion changes, so do the colors. We have a familiar example in the spotted breeds of Channel Island cattle changing to uniformity under the fashion for "solid colors" now prevailing.

With mongrel stock, if spotted and party-colored, as they are apt to be from their mixed ancestry, there is still a tendency towards bilateral symmetry in a majority of cases, as any one may easily prove by carefully comparing the markings on the two sides, the feet, the ears, the line on the back, etc., of a number of spotted animals. This is even true of a considerable number of calico horses I have observed, not so symmetrically disposed as the two sides on the markings of a zebra, to be sure, yet a disposal of marks as if there was an effort in the direction of bilateral symmetry.

Each of the points in this paper I purpose to elaborate more in detail at some future time, from data already at hand.

PILOCARPIN AND ITS ACTION IN CHANGING THE COLOR OF THE HUMAN HAIR. By D. W. PRENTISS, of Washington, D. C.

[ABSTRACT[1].]

PILOCARPIN is an alkaloid of jaborandi and the active principle. Jaborandi is a Brazilian drug recently introduced into medicine. The leaves are the officinal part of the plant (*Pilocarpus pennatifolius*). The effect upon the human system is powerful and peculiar. It produces profuse sweating and profuse salivation, and stimulates the growth of the hair.

Two cases were reported. In the first case, the medicine was given to relieve uræmia, consequent upon suppression of urine due to *Chronic Pyelitis*. The patient was a lady, twenty-five years of age, a blonde of petite figure.

The pilocarpin (hydrochlorate) was administered by hypodermic injection commencing Dec. 16, 1880, and being continued at intervals until Feb. 22, 1881. The usual dose given was one centigram, but on several occasions this dose was doubled. The object of its use was to eliminate urea from the system by sweating and salivation.

The immediate effect produced was profuse sweating and salivation calculated to amount to not less than fourteen pints. (See Phila. Med. Times July 2, 1881.)

The result to the patient on each occasion was great exhaustion, but the uræmic symptoms were relieved. Twenty-two "sweats" were administered in all, and from thirty-five to forty centigrams of pilocarpin were used.

CHANGES IN THE COLOR OF THE HAIR.

Specimens of the hair were exhibited to the section, as also a colored plate showing the changes in color. Two specimens, dated respectively, Nov. 1879 and Nov. 1880, were of a very light color tinged with yellow, and showed that the color of the hair had not changed during that year.

The third specimen dated Jan. 12, 1881 was a chestnut brown and the fourth, dated May 1881, almost pure black.

The administration of the pilocarpin began Dec. 16, 1880; the

[1] This paper is printed in full, with a colored plate, in the Cincinnati Lancet and Clinic of Sept. 3, 1881.

ange was first noticed Dec. 28, 1880, and was thenceforth pro-essive.

In addition to change of color the hair has become thicker and arser than formerly, and while previously dry, it is now quite y.

The hair on other parts of the body is also changed in color. e eyes have become a much darker blue.

In the second case, the pilocarpin was administered to an infant irteen months of age, afflicted with membranous croup. (See ila. Times, Aug. 13, 1881.)

The treatment was commenced June 9, 1881; two milligrams hydrochlorate of pilocarpin being given every hour, afterwards reased to four milligrams every hour. It was administered for ie days, the amount being diminished towards the last.

The first specimen of hair was taken June 17, 1881, and the ond, June 27, 1881. The color of the first is light yellow, and second is a decided shade darker.

This effect, of changing the color of the hair, if subsequent ex-rience shall confirm it, adds another to the marvellous influences jaborandi on the human system.

The *modus operandi* of the change is still to be determined. It probably connected with the fact that jaborandi stimulates the trition of the hair.

There appears to be reason to believe that the color of hair is e to an oily pigment, and that this is increased under the influ-ce of jaborandi.

Shaving the scalp usually has the effect of making the hair icker and darker. On the contrary, as age advances, and the ocesses of nutrition are enfeebled, the hair becomes thin, dry d whitens.

IE SUCCESSFUL ADMINISTRATION OF NITROUS OXIDE, AS AN ANÆSTHETIC FOR DENTAL AND SURGICAL OPERATIONS. By E. P. HOWLAND, of Washington, D. C.

[ABSTRACT.]

THE successful administration of nitrous oxide consists in ad-nistering it to patients in such a manner that during operations ey will not suffer pain and that they will be in such a condition

that the dentist or surgeon can successfully perform the operation, and afterwards that the patients are found not to be injured by its administration.

The first requisite for success is that the nitrous oxide should not have more than one per cent. of pure oxygen or three per cent. of atmospheric air, and that it should be perfectly free from all other gases or vapors. Nitrous oxide with two per cent. or more of pure oxygen or five per cent. or more of atmospheric air will not produce perfect anæsthesia, and the patient will feel the pain of the operation and pronounce the gas a failure. The adding of one per cent. of pure oxygen to nitrous oxide has the benefit of partially oxygenating the blood and in a measure preventing the spasmodic action of the muscles and at the same time producing satisfactory anæsthesia. According to experiments made in France by P. Bert, ten per cent. of oxygen or fifty per cent. of atmospheric air can be added to nitrous oxide to oxygenate the blood and at the same time produce perfect anæsthesia if it is breathed in a chamber under a pressure of two atmospheres. A certain amount of nitrous oxide taken into the lungs is necessary to produce insensibility; and it can be diluted with any innocuous gas and still produce anæsthesia, provided this amount is inhaled in the given time. Under pressure in a chamber more gas is breathed in a given time as the nitrous oxide is condensed the same as the air in the chamber, and under a pressure of two atmospheres two volumes of nitrous oxide would be condensed into one volume so that the nitrous oxide could be diluted with equal measures of atmospheric air, and still the quantity of nitrous oxide inhaled would be the same as if breathed ordinarily, and the quantity of oxygen breathed sufficient to arterialize the blood. Rapid breathing of nitrous oxide produces quick anæsthesia, but nothing is gained by it in practice. It is very difficult to produce anæsthesia with nitrous oxide at high elevations above the ocean, because the low pressure of the atmosphere allows the gas to expand so that a less quantity is taken into the lungs in a given time than is required to produce insensibility. Valve inhalers have generally proved a failure because they admit atmospheric air with the gas in sufficient quantity to prevent perfect anæsthesia. As near as I can ascertain more than one-half of all the dentists of the United States who have used nitrous oxide have abandoned its use on account of want of success in producing satisfactory insensibility,

nd thereby injuring instead of benefiting their practice. One ause of failure is the unskilful administration of the gas in al-wing air to be inhaled with it, by not having the lips closed tight round the inhaler, and other causes; not using the nose as a valve r expiration exactly at the right time, not stopping the adminis-ation at the point of greatest anæsthesia, and not having suffi-ent self-possession under all circumstances and emergencies to now just what to do and when to do it. But the greatest cause the failure to produce perfect anæsthesia from the mixture of mospheric air in the nitrous oxide that has been kept in a gas-meter over water for a few days. The gas becomes mixed with air rough the medium of the water and defective gasometers and ocks.

The trouble and cost of making fresh gas every few days has aused the great abandonment of its use. Skilful administrators ho have a large practice and use gas before it is deteriorated y air are making nitrous oxide a success. Other dentists can ake gas a success by obtaining it condensed in cylinders when e gas will keep unadulterated and unchanged for years.

The only drawback to a paying success is the present great ost of the condensed gas, which in the small cylinders amounts about thirty-five cents for each administration, when the gas an be made in the dentist's laboratory for about three and a half ents for each administration. An apparatus can now be obtained at enables each dentist to make and condense his own gas and eep it for any length of time. Physicians and surgeons do not se nitrous oxide on account of the trouble and cost of making nd keeping it, and the greater amount of practice and skill quired in its successful administration than the more dangerous her and chloroform. Nitrous oxide requires a costly apparatus manufacture it and bulky receptacles from which to administer , and the gas is for sale in but two places in the United tates, while ether and chloroform can be carried in a bottle in e pocket and purchased at every drug store in the land. Nitrous xide can be administered with almost absolute safety, while ether d chloroform can point to their victims in every city and hospi-l. Money, labor and skill can make nitrous oxide successful ith both dentist and surgeon, and taking into account the value f human life, nitrous oxide should stand at the head of all anæs-etics, and its practical use be encouraged instead of ether and hloroform.

I have administered nitrous oxide in over thirty thousand cases for dental and surgical operations and have had uniform success. I have never had a case of injury from lung or heart disease, but in many cases of throat and lung diseases a marked and permanent improvement. I have kept a large number of patients perfectly anæsthetic for surgical operations from five to thirty-five minutes, and the pulse during these operations has been nearly uniform and full. The success of prolonged operations consists in first producing perfect anæsthesia, and then breathing air to arterialize the blood and before consciousness returns again breathing nitrous oxide, the necessary intervals varying in different patients from one-fourth to one-half minute. The average length of time occupied in dental operations from the first commencement of breathing the gas till return of consciousness has been two minutes. To encourage and make nitrous oxide a greater success in the future, the dental and medical colleges should employ successful operators to lecture and instruct graduates so that the particular knowledge and skill acquired by them in practice, can be learned by others.

TITLES OF OTHER PAPERS READ IN SECTION B.

CANONS AS I HAVE SEEN THEM, WITH SOME THOUGHTS AS TO THEIR ORIGIN.[1] By Wm. Bross, of Chicago, Ill.

THE UNIFICATION OF GEOLOGICAL NOMENCLATURE.[2] By Richard Owen, of New Harmony, Ind.

RECENT DISCOVERIES, MEASUREMENTS, AND TEMPERATURE OBSERVATIONS, MADE IN MAMMOTH CAVE, KY.[3] By H. C. Hovey, of New Haven, Conn.

THE LIFE UNIT IN PLANTS. By Byron D. Halsted, of New York, N. Y.

[1] Printed in full in Chicago Tribune of Aug. 25, 1881.
[2] An abstract of this paper is printed in Science for Sept. 17, 1881.
[3] Printed in the Scientific American of Oct. 8 and 29, 1881.

HE OCCURRENCE OF CRETACEOUS FOSSILS NEAR MOUTH OF ILLINOIS RIVER. By Wm. McAdams, of Otterville, Ill.

ME NEEDED REFORMS IN THE USE OF BOTANICAL TERMS.[4] By Charles E. Ridler, of Kingston, Mass.

IGITAL DIFFERENTIATION. By A. J. Howe, of Cincinnati, Ohio.

VOLUTION, AND ITS PLACE IN GEOLOGY. By Edward S. Edmunds, of La Grange, Ind.

OTE ON THE SEGMENTATION OF THE VERTEBRATE BODY. By Charles Sedgwick Minot, of Roslindale, Mass.

N SOME RELATIONS OF BIRDS AND INSECTS. By S. A. Forbes, of Normal, Ill.

IAGARA RIVER. ITS CANON, DEPTH, AND WEAR. By William Hosea Ballou, of Evanstown, Ill.

N THE RELATIONS OF THE GROWTH, SIZE, AND AGE OF ANIMALS. By Charles S. Minot, of Roslindale, Mass.

ATURAL FILTRATION OF WATER FOR DOMESTIC USE IN CITIES. By G. C. Swallow, of Columbia, Mo.

OTICE OF A FERN INDIGENOUS TO CALIFORNIA, BUT HERETOFORE CONSIDERED AS AN INTRODUCED HOT-HOUSE SPECIES. By Mrs. Leander Stone, of Chicago, Ill.

OSSIL TEETH OF MAMMALS FROM THE DRIFT OF ILLINOIS. By Wm. McAdams, of Otterville, Ill.

N THE SUPPOSED RECENT EXISTENCE OF SWORD-FISH, SHARK, AND DOLPHIN IN THE FRESH WATER POND NEAR BUFFALO, N. Y. By Wm. Zimmerman, of Buffalo, N. Y.

. REVISION OF THE ANATOMY OF THE ETHMOID BONE IN THE MAMMALIA.[5] By Harrison Allen, of Philadelphia, Pa.

[4] An abstract of this paper is given in Science for Sept. 10, 1881.
[5] Published in full in the Bulletin of the Museum of Comparative Zoölogy.

PERMANENT

BSECTION OF ENTOMOLOGY.

ADDRESS

BY

REV. JOHN G. MORRIS, D. D.

CHAIRMAN OF THE SUBSECTION OF ENTOMOLOGY.

I REGRET exceedingly that I am compelled to begin my address by the recital of a melancholy event in the history of our Section.

About ten days after our adjournment last year, and probably after we had all arrived at home and settled down to our autumn's work, the distressing intelligence reached us of the sudden death of one of our most honored and distinguished members. He had mingled with us at Boston and had taken part in our deliberations, and though cheerful and full of hope, yet his usually buoyant temperament was plainly mellowed by advancing years, the every-day anxieties of life, and the pressure of severe intellectual pursuits. He returned home after our adjournment and immediately resumed his linguistic studies with his usual incessant ardor, — for he often said to me: "I never take exercise when I am at home, but work all day and sometimes late into the night,"— and on Sept. 1, 1880, Samuel Stehman Haldeman was suddenly stricken down. His lamented death has been noticed in most of the leading papers and scientific journals of the country, accompanied with some biographical facts, for he was widely known as a scholar and scientist, and no man was more highly esteemed as a companion and gentleman. We are all aware of the distinction he achieved in letters and science in our own and foreign countries, of the learned books and papers he has written, and of the titles and prizes which his works secured for him.

If this were the proper place, it would be pleasing to dwell, even at length, upon the many valuable traits of his character, the vast extent of his diversified acquirements, and his almost unparalleled qualities as a friend and scientific fellow-laborer. I feel as if I were announcing the death and reciting the admirable virtues of

a brother. For forty years he and I were what may properly be called "bosom friends." In early life we were engaged in similar scientific pursuits, and living but a few hours' distance from each other, our mutual visits were frequent and our warmest friendship and confiding intercourse continued uninterrupted to the end.

It is well known that in early life he devoted much of his time to our favorite science, to which he made some valuable contributions. His principal papers are: Materials toward a History of Coleopterous Longicornia of the United States; Corrections and Additions to this paper; Description of North American Coleoptera; Cryptocephalinorum Borealæ Americanæ Diagnosis. These papers give evidence of honest and painstaking research, patient analysis and sharp discrimination and are profitably consulted by investigators at the present day.

Of late years, he had turned his attention particularly to the study of Language, and became a distinguished member of the Philological Society. All readers know the celebrity he attained in that department and the ardor with which he pursued those studies; notwithstanding their engrossing attractions, he never ceased to feel an interest in everything that concerned our department. It is hard for a man to forget his first love.

Thus much I thought it proper to say of the lamented Haldeman. He was no ordinary man whom you might compliment with a passing respectful obituary notice. In science and letters he was a great man. His memory will be long cherished by admiring friends. "*Idem extinctus amabitur.*" It may not be out of place to mention here one fact, to me at least, personally interesting. Less than two months ago the monument of Haldeman, chiselled out of enduring granite by Strecker, a brother entomologist, was erected over his grave by the pious care of the skilful artist himself, who spends his days in cutting marble and granite into classic forms, and half of his nights in studying and figuring the butterflies of his own unequalled private collection.

Gentlemen, forty years ago I could count the known working entomologists of our country with the first ten numerals. The older Melsheimer, who may properly be designated as the father of our science in this country, Say, Peck, Gould, Randall, Peale, and a few other pioneers, had died or retired, and the only workers then were Harris of Cambridge; Major LeConte and his son John L., of the City of New York; Fitch, of the state of N. Y.; Haldeman,

[elsheimer, jr., and Zeigler, of Penna., with a few others of no pecial note, were the only ones, as far as is at present recollected, ho prosecuted our science with any zeal and who contributed to its rogress by the descriptions of species. There were others who ollected insects, but they made no claim to be scientific entomolgists. I remember distinctly when Melsheimer, Haldeman, Zeiger and I used to meet several times a year at our respective homes o read papers, discuss questions, exhibit new species, recite our ntomological adventures and then adjourn to a well appointed able. We regretted that we had no collaborators within two hunred miles, for the LeContes in New York were our nearest neighors. In that day there was not a man in Philadelphia who studed insects. We then established "The Entomological Society of 'ennsylvania," and after electing all our *confrères* in this country s honorary members, we had the audacity to confer the same disinction upon some great men abroad, whose letters of grateful cceptance indicated that they thought that the Society was somehing more than a club of four comparatively unknown men meetng in Haldeman's study on the banks of the Susquehanna!

And now look at the mighty change. In the Naturalists' Direcory for 1880 there are no less than 436 names reported as pursuing ur science. Now, while it is true that many of these may be colectors only, still they are more or less useful. They all must be nterested in it to a greater or less extent, or they would not have eported themselves as such. Be this as it may, the increase is imply wonderful and very encouraging. Doubtless there are umerous others in the country engaged in the same delightful emloyment whose names do not appear in the directory.

There is no other distinct branch of science that has so many epresentatives in that book as ours, excepting botany and geolgy, and in zoology specially we are ahead of the ornithologist y over fifty; the conchologists are fewer than one hundred all old, and all other specialists in zoology are behind us. All this s cheering, and we are sure that the number of collaborators is rowing every year.

But there is a still more encouraging view of the subject, which s founded not only on names, but on facts, and I am sure it will ratify the Section to hear of the number of the published contriutions of our fellow workmen. True, they are not all members f this Section, but they belong to the family and we hail them as rethren of the same household.

Most of us have, of course, kept our eyes upon the various journals and have been pleased to see so many papers, and yet perhaps few of us have any proximate conception of their number and variety. Hence I have thought that probably the most acceptable contribution I could make at this meeting would be a complete list, as far as was possible, of all American entomological writers since our meeting in August last, and this I have done and will present it at the proper time. Some names may have been inadvertently omitted, but these can be subsequently introduced. In order to insure perfect accuracy and fulness I made the list of each author's writings as far as I could find them and sent it to him for correction, and I here desire to thank those gentlemen for the uniform courtesy with which they granted me their aid.

This paper will give us a better idea of the progress of our science during the past year than any other mere description possibly could.

A brief analysis of it gives 77 writers and 128 titles; 25 of these articles treat of Coleoptera; 19 of Lepidoptera; 15 of Orthoptera; 5 of Neuroptera; 10 of Diptera; 11 of Hymenoptera; 11 of Hemiptera; 10 describe larvæ of various orders; 6 are on fossil insects; 5 on Myriopods and spiders, and 10 on Economic Entomology.

This brief exhibit will give an idea of what has been done as far as has been made public. Doubtless there are many other papers in preparation, and much efficient work has been privately done which may never be published.

It would be out of my province to specify any of these writings in this address, and much more to express any opinion of their relative value, or to indulge in any critical remarks. That must be left to the reviewers.

We now have four journals exclusively devoted to our science, and in several others considerable space is allotted to it. In connection with these must be mentioned the annual reports of the state entomologists. The Proceedings and Transactions of all Natural History Societies also contain frequent articles upon the subject.

The Canadian Entomologist, Psyche, the Bulletin of the Brooklyn Entomological Society, and Papilio, should be supported by every one of us. Indeed, no man can know how our cause is advancing without them, and as it is likely that none but entomologists read them, so much the more general should be our patronage that they may be maintained.

Each of these four seems to occupy its peculiar field. The Canadian is general and the organ of a special association. Although it is geographically *extra limital* yet it is very near to us and a large share of its original papers come from this side of the Niagara. We claim it as one of our own, and being the oldest and admirably conducted, we hope that its present efficient editor may long continue to conduct it and render it still more interesting and instructive.

The next oldest is Psyche, and in relation to it I may quote what our first President said in his opening address: "Psyche, though small, is indispensable to every one occupied with the insects of North America." It covers a ground not occupied by any other periodical in the world, and it is very creditable to the disinterested labors of American entomologists. Its accuracy has never been questioned, and it is extremely desirable to secure its continuous publication. You know that it was begun by the Cambridge Entomological Club, which is really the parent of the Club of the A. A. A. S., which has been elevated to the dignity of a Subsection. The Cambridge Club differs from some others in the country in freely granting the use of its library to entomologists throughout the whole country, and hence it is very desirable that the library should be enriched and the Club thus enabled to extend its benefits still more widely.

The Bulletin of the Brooklyn Entomological Society is a spirited publication, displaying much zeal, correct diagnosis and careful description.

Papilio, the youngest of the family, is entirely devoted to Lepidoptera and thus occupies an exclusive field and cultivates it successfully. The necessity for it arose, I apprehend, from the fact that our investigators had so much that was new to publish, that room could not be found in the other journals; and when we consider that the number of our writers is increasing every year and new discoveries are constantly made, it is plain that all the journals now in existence among us could not publish all the communications unless the journals were greatly enlarged. As it is likely that all these editors render their valuable services gratuitously, and that the present patronage would not justify an enlargement, we shall have to be content for some time to come with their present size.

The American Entomologist, under the able editorship of Pro-

fessor Riley was published to the end of the year, and while it has since ceased to appear, its place is partially taken by a special department devoted to our science in the American Naturalist. This department is under the efficient management of the same distinguished writer.

In conclusion, I will make bold to throw out one or two suggestions.

First, in view of the wonderful progress which our science has made in this country, has not the time come for condensed, complete, systematic books on each of the Orders, after the style of many German books that might be mentioned? Every one of us is often asked by beginners: What book would you recommend on beetles? And our answer is: there is none which contains descriptions of all our known species in systematic order, but you must gather them from various monographs, journals and proceedings, which are not easy to procure. This disheartens the young student. The same is to a great extent also true of butterflies, especially of Noctuidæ, and of other Orders of insects, although the want is supplied in Lepidoptera more fully than in any other. But even this Order, beyond the Diurnals, although hundreds of species are described, has not been brought together in systematic arrangement. The material is at hand, and nothing is wanting but a competent editor and an accommodating publisher to bring out a series of works which would contribute immeasurably to our progress.

My second suggestion is, that it would be interesting to know the extent, character and condition of the larger public and private collections in the country, with a mention of the varieties they contain. This might embrace two sections, those of our own species and those of foreign countries. A paper on this subject for the next meeting would be an interesting contribution, and I hope some gentleman will furnish it; or let some member be appointed, so that there may be no conflict and the whole field be open to him. No doubt the owners of private collections and the curators of public ones would cheerfully render him their counsel and aid.

And now, gentlemen, congratulating you upon our meeting again, let us proceed to our business and prosecute it with vigor, patience and order.

PAPERS READ.

A REMARKABLE INVASION OF NORTHERN NEW YORK BY A PYRALID INSECT, CRAMBUS VULGIVAGELLUS. By J. A. LINTNER, of Albany, N. Y.

[ABSTRACT.]

IN May of the present year, the grass in the pastures of several of the counties of northern New York was observed to turn brown in patches. This appearance rapidly spread, until it extended over entire fields. Examination disclosed the fact that all the grass had been eaten by a small caterpillar which was discovered concealed, for the most part, in the ground. Hundreds of acres were overrun, and the grass completely destroyed in a very short space of time. It was generally ascribed to an invasion of the *army-worm*. I visited the region and examined the insect and its operations. I could not refer it to the army-worm, *Leucania unipuncta*, with which it did not agree, but it seemed possible that additional moltings might prove it to be that species. My attempts to rear the larvæ for the identification of the moth failed. Additional collections, at my request, were made for me in St. Lawrence county, which were said to be an advanced stage of those which I had observed during my visit. Some of these were submitted to Professor Riley and were by him identified as *Nephelodes violans*. I accordingly in some communications sent to newspapers, narrating this remarkable insect invasion, ascribed it to that species. Subsequent study of my alcoholic larvæ led me to believe that I may have been hasty in my reference. Early in July, from letters and numerous cocoons received from Watertown, N. Y., where the attack had also prevailed, it was evident to me, that the real author of by far the greater portion of these extensive ravages was a member of the family of Pyralidæ, and that *Nephelodes violans* had merely been associated with it, to a quite unusual extent, in a portion of the invaded district.

The moths from the cocoons received from Watertown commenced to emerge during the first week of August, and disclosed

the fact that the very serious injuries inflicted upon the pasture lands throughout eight of the northern counties of the state of New York — at first popularly ascribed to the *army-worm*, and later, erroneously, by myself to *Nephelodes violans*, were in reality chargeable upon the modest, inconspicuous and hitherto unobtrusive species, *Crambus vulgivagellus* Clemens.

It is believed that the same species is the author of serious destruction of pasture lands reported, during recent years, from some of the New England states. The knowledge of its history now obtained will enable us to recognize its attacks hereafter.

On the Life duration of the Heterocera. By J. A. Lintner, of Albany, N. Y.

[ABSTRACT.[1]]

This paper is offered as a supplement to that of Mr. W. H. Edwards, "On the Length of Life of Butterflies." The length of time passed by our moths in their perfect stage has not been made a subject of special inquiry, and very few published observations bear upon it. Those made upon individuals in confinement would necessarily give but approximate results. As yet, we know the life histories of comparatively few of our species. Of the large family of Noctuidæ, it is believed that not an entire brood of a single species has been raised from the egg. Of the Bombycidæ and the Sphingidæ the eggs are easily to be obtained, and we consequently have more ample knowledge of them. Among the Attacinæ of the former family, the sexes mate a few hours after emerging from the pupæ, and the female begins to deposit eggs the following day. She dies soon after the completion of the oviposition,—after a life of some twelve or fifteen days. The male dies soon after copulation, some days before the female. In the Sphingidæ we know that the lives, while brief, are longer than those of the Bombycidæ. An approximation to the life period of the Noctuidæ is to be obtained from the dates when the

[1] This paper is given in full in the Canadian Entomologist for Nov., 1881.

ecies are observed abroad. The several lists that have been iblished of collections made "at sugar," furnish convenient and :cellent data for the purpose. From a careful examination and mpilation from a number of such lists and other records, it ap- ars that there are many of our common Noctuas, among *Agrotis*, *'amestra*, *Hadena*, etc., which are abroad for about one month. educting from this period for unequal emergence from pupa and her causes, it is believed that the estimation of a life period of *ree weeks* for these forms cannot be far from correct. In this eterogeneous family, however, this period must necessarily be aite varied. In such genera as *Xylina*, *Homoptera*, *Catocala* and thers, it is much longer. Several species of *Catocala* are recorded s having been observed for periods varying from forty-five to fty-seven days.

It is very desirable that all lists of our insects, to be hereafter ublished, shall include the several dates of their collection or bservation throughout the entire time of their appearance. Such iformation will be of much service to general entomology, and rove of particular value in economic investigations.

IFE-HISTORY OF THE BUCKEYE STEM-BORER, SERICORIS INSTRUTANA, CLEM. By E. W. CLAYPOLE, of Yellow Springs, Ohio.

[ABSTRACT.]

THIS paper which has, since it was read, appeared in the pages ' "Psyche," the journal of the Cambridge (Mass.) Entomologi- il Society, consisted of a report of several attempts to trace the fe-history of the insect. The caterpillar is found in spring, about ie beginning of May, in the leaf-stalk of the Buckeye tree almost s soon as the leaves are unfolded. On only one occasion was it und in the young twig. After spending a few days in this nar- w dwelling, it comes out apparently to obtain more roomy quar- rs and takes up its abode in the leaf, now withering on account of ie injury to the stalk. On this it feeds and in about three weeks hanges to a chrysalis, in which state it remains for a fortnight or

so, and then issues in the perfect state. The investigation was undertaken with a view to determine the cause of the drooping and withering of so many leaves of the Buckeye tree in the spring. This withering of the leaves gives the tree a peculiar appearance, and is calculated to arrest the eye of an entomologist. For full details consult "Psyche" for 1881.

RETARDED DEVELOPMENT IN INSECTS. By C. V. RILEY, of Washington, D. C.

[ABSTRACT.]

IN this paper the author records several interesting cases of retarded development in insects, whether as summer coma or dormancy of a certain portion of a given brood of caterpillars, the belated issuing of certain imagines from the pupa, or the deferred hatching of eggs. One of the most remarkable cases of this last to which he calls attention is the hatching this year of the eggs of the Rocky Mountain Locust, or Western grasshopper (*Caloptenus spretus*) that were laid in 1876 around the Agricultural College at Manhattan, Kans. These eggs were buried some ten inches below the surface, in the fall of 1876, in grading the ground around the chemical laboratory. The superincumbent material was clay, old mortar and bits of stone, and a plank sidewalk was laid above all. In removing and regrading the soil last spring, Mr. J. D. Graham noticed that the eggs looked sound and fresh, and they readily hatched upon exposure to normal influences, the species being determined by Mr. Riley, from specimens submitted by Mr. Graham. Remarkable as the facts are, there can be no question as to their accuracy, so that the eggs actually remained unhatched during nearly four years and a half, or four years longer than is their wont, and this suggests the significant question: How much longer could the eggs of this species, under favoring conditions of dryness and reduced temperature, retain their vitality and power of hatching?

Putting all the facts together, Mr. Riley concludes that we are

s yet incapable of offering any very satisfactory explanation, ased on experiment, of the causes which induce exceptional etardation in development among insects. It is a very general ule that a rising temperature stimulates and accelerates growth, hile a falling temperature retards and torpifies, and experiments ecorded by the author[1] show that such is the case with regard to e eggs of *Caloptenus spretus*. But there are many strange exeptions to the rule. The eggs of Crustaceans as those of *Apus* nd *Cypris* are known to have the power of resisting drought for ix, ten or more years without losing vitality, while in some cases ey seem actually to require a certain amount of desiccation beore they will hatch. Yet the fact remains that different species ct differently in this respect. In short, nothing is more patent o the observing naturalist than that species, and even individuals f the same species, or the progeny of one and the same indiidual, act very differently under like external conditions of exstence; in other words, that temperature, moisture, food, etc., nfluence them differently. Hence, as has been shown by Semer to be the case with other animals, so it is with insects, hanges in the external conditions of existence will not affect the auna as a whole equally but will act on individuals. We can unlerstand how this great latitude in susceptibility to like conditions ay and does in the case of exceptional seasons prove beneficial the species by preserving the exceptional individuals that dislay the power to resist the unusual changes, but we shall find rselves baffled when we come to seek a demonstrable explanation the cause or causes of such retardation; while the principles of olution afford us the only hypothetical one at all satisfactory. the innate property of organisms to vary and in the complex enomena of heredity we get a glimpse at the cause—a partial planation—of the facts of retarded development, for the exptional tendency in the present may be looked upon as a manifestion through atavism of traits which in the past had been more mmonly possessed and more essential to the species. This pothesis is strengthened by the fact that the period of two, ree or more years occupied in full development by exceptional dividuals of a species which normally goes through its transforations within one year, is, at the present day, the normal period other species belonging often to the same natural order.

[1] 9th Rep. Ins. of Mo.; also 1st Report U. S. Ent. Comm.

On the Oviposition of Prodoxus decipiens. By C. V. Riley, of Washington, D. C.

[ABSTRACT.]

In his paper treating of this insect, read at the Boston meeting, the author stated that oviposition had not been observed. He has studied it carefully the past summer, and finds that, as the structure of the ovipositor would indicate, the female stations herself lengthwise with the axis of the stem usually head upward, and literally saws through the epidermis with an up and down motion just such as a carpenter would make in endeavoring to work the tip of an ordinary hand-saw into the trunk of a tree. She never has anything to do with the stigma of the flower as *Pronuba* does, and the important and interesting fact is recorded that the eggs of *Prodoxus* are all inserted while the stem is soft and before the flowers begin to open, *i. e.*, before *Pronuba* usually appears. As soon as the flowers begin to open (in *Yucca filamentosa*, the species upon which the observations were made), the stem has become too hard to permit the female to do her work, and the species has for the most part disappeared, only a few belated individuals being subsequently found, and these, so far as could be observed, perishing without issue. In experiments made to test the matter it was found that where a female succeeds in inserting the ovipositor into a stem that had become hard, she perished in the effort to disengage herself and remained firmly attached to the stem.

New Insects Injurious to Agriculture. By C. V. Riley, of Washington, D. C.

[ABSTRACT.]

Almost every year the appearance of some insect or insects injurious to agriculture, but previously unknown in an injurious capacity, has to be recorded. The present year (1881) has afforded several striking examples, as *Crambus vulgivagellus* which has seriously injured pastures, and *Phytonomus punctatus* which has proved destructive to clover, in the state of New York.

A new Pyralid has also very generally ravaged the corn plants

in the southern states. These new destructive species may either be (1) recently introduced species from some foreign country, (2) native species hitherto unobserved or unrecorded, and new in the sense of not being described, or (3) native species well known to entomologists, but not previously recorded as injurious.

The author argues that in the last two categories, more particularly, we frequently have to deal with newly acquired habits, and in the second category with newly acquired characters that in many cases systematists would consider of specific value. In short, he believes that certain individuals of a species, which has hitherto fed in obscurity on some wild plant, may take to feeding on a cultivated plant, and with the change of habit undergo in the course of a few years a sufficient change of character to be counted a new species. Increasing and spreading at the rapid rate which the prolificacy of most insects permits, the species finally becomes a pest and necessarily attracts the attention of the farmer. The presumption is that it could not at any previous time have done similar injury without attracting similar attention; in fact that the habit is newly acquired. The author reasons that just as variation in plant life is often sudden, as in the "sport," and that new characters which may be perpetuated are thus created; so in insects there are comparatively sudden changes which under favoring conditions, are perpetuated. In this way characters which most systematists would consider as specific, originate within periods that are very brief compared to those which evolutionists believe to be necessary for the differentiation of specific forms among the higher animals.

THE SYRIAN BEES. By A. J. COOK, of Lansing, Mich.

A LITTLE less than two years since, two American gentlemen, D. A. Jones, of Canada, and Frank Benton, of Michigan, started for the old world in quest of new races or species of bees, with the hope that they might discover and introduce into America some new and valuable races or species. After visiting the principal apiaries of Europe, they located in Cyprus, where they established a large apiary in the city of Larnaca. Mr. Benton remained in Cyprus, in charge of the bees, which consisted of two distinct varie-

ties, the Cyprian and the Syrian, while Mr. Jones returned to America in June, 1880, bringing a large number of the queens of the two races with him.

The following winter Mr. Benton proceeded to Ceylon and Java, hoping to find "the great bee of Java," *Apis dorsata*, and perhaps others that were valuable. His quest on the Island of Java was very thorough, but utterly fruitless. No sign could he see or word could he hear of the great "Javan bee," *Apis dorsata*. It was not there, and Mr. Benton gained the expensive information that the name Java, as applied to this species, was a serious misnomer. His search in Ceylon, however, was better rewarded, as he procured on this island, after severe labor, great privation, and serious hardships, which came near costing him his life, two new species of Apis: the large *dorsata* which fastens its immense combs, all exposed, to the underside of the branches of trees, and the minute *florea*, which nests in the hollows of trees and rocks, as do our common bees. The comb of *Apis dorsata* is very thick and heavy, while that of *A. florea*, some of which I have received through the kindness of Mr. Benton, is very delicate and beautiful. The cells are one-third less in diameter than are those of our common bees.

Upon the arrival of the new queens in America, I at once procured one of the Syrians, and Syrianized the entire apiary at the Michigan Agricultural College, as I could then learn their peculiarities with much more certainty than if I had kept several races.

As the Syrian is the only one of the new races and species with which I have had personal knowledge, I will confine the balance of this paper to it, reserving the description of the other species and race for a future occasion.

The Syrian bees are of the yellow type, and so are closely related to the Italians. Indeed, there are reasons to believe that these latter bees are the modified offspring of the Cyprians, which as probably were the descendants of the Syrians.

The queens of this race are remarkably uniform in coloration, and thus appear more fixed as a variety, than do the Italians, whose queens are quite variable in color. This uniformity is so striking that of twenty Syrian queens which I have reared, it is next to impossible to distinguish one from another. The head, thorax, femora, and bands on the dorsal surface of the abdomen are black—

he abdomen above is brown or leather-color, while the legs, :cept the femora, and the under side of the abdomen, are a little ghter. The black bands on the back border posteriorly the segents from the second to the fifth inclusive. They broaden from fore back to the last, which nearly covers the fifth segment. he second and third bands are a little broadest in the middle, d the last segment is wholly black. In form the Syrian queens e essentially like the Italians, nor do they differ in size.

The drones are black above and yellowish-brown beneath. The gs are black. Each segment of the abdomen is bordered above steriorly with golden brown. Olive brown hairs cover the thox above, while beneath the thorax on the under side of the head, d at the base and tip of the abdomen, the hairs are of a lighter e. These drones are also unlike the Italian drones in their wonous uniformity. Each seems exactly like every other. The Syan and Italian drones do not differ in form and size. In breeding ese bees I have had striking proof that impregnation has no effect modify the drones. The first four queens that I reared must ve mated with Italian drones, as there were no others in the apry, and no Syrian drones in the state. Yet of a great number of rones from these queens, not one was seen that did not show the arks of a pure Syrian in every respect.

The Syrian workers are like those of the Italians, except that ey are more yellow beneath; this color prevailing to the last gment which is dark. The young Syrians, just as they come om the cells, appear very dark. This peculiarity furnishes the adiest means by which to identify these bees when there are no rones in the hive. The workers are a little brighter than are the alian workers, and perhaps a trifle smaller. The tongue of the yrian worker I find, after examining a large number of each kind, be of the same length as that of the Cyprian, and to average 06 of an inch longer than that of the Italian, and more than .02 n inch longer than the tongue of the German worker.

I have found the Cyprian bees to be very prolific, and persisttly so. Autumn frost or summer dearth of honey secretion es not check brood rearing as is the case with the Germans or alians. This does away with all need of stimulative feeding, d keeps the colonies strong at all times. Young bees are prest at dawn of winter which is an important adjunct in safe winring, and a safeguard against spring dwindling. The Syrians re excellent honey gatherers, certainly equal, if not superior, to

the Italians. They are even more sure to repel robbers than are the Italian bees.

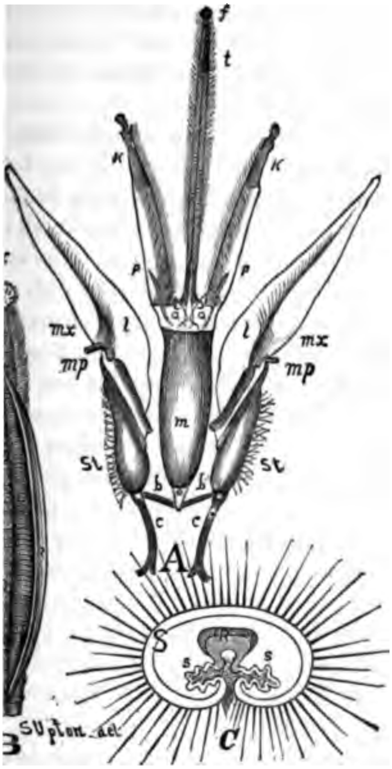
Some of the characteristics of the Syrians are not so desirable. They fairly crowd the queen cells when preparing to swarm. Sometimes five or six queen cells will be massed in one great pyramid; so it is often difficult to separate them without ruining large, fine cells. The speedy destruction of the remaining queen cells after the first queen comes from the cell, and the quick appearance of fertile workers in queenless colonies and nuclei, are objectionable features. These bees are more irritable than are Italians, and worst of all when once aroused, they are totally indifferent to smoke, and fight on all undismayed, even in the presence of the best Bingham smoker. This objection is not very serious, however. The bees are breeding at all times, and so are almost always peaceable, so much so, that I have handled them now for a year, without gloves, veil or smoke, and with no fear or annoyance, except in case of colonies or nuclei which had no queens. Queenless colonies are often very irritable. By waiting a little after opening the hive we are safer, but even then it is not always agreeable to handle them without full protection. Fortunately it is not necessary to handle them much at such times. It is much easier to protect fully these few times, than to have to use the smoker most of the year. After a year's experience, I can give hearty praise to these bees, which are certainly a most valuable acquisition to American apiculture.

How the Bee Extends its Tongue. By A. J. Cook, of Lansing, Mich.

[ABSTRACT.]

Figure 1, taken from my Manual of the Apiary, gives an accurate idea of the structure and parts of the tongue of the honey bee. *A* gives the parts as they appear when extended; *B* shows the ligula with the tubular sheath (*s*) fully extended, and *C* shows a cross section of the ligula when the sheath is not extended. In this figure, *ss* represents a colorless membrane, which is usually folded as seen in the figure, but which is put on the stretch, when the sheath is distended as seen in *B*. The central rod (*r*) is essen-

ly a tube, as I showed two years since in the American Bee rnal, vol. 15, page 490; but it is slitted below, so that by the of the muscle *r*, in *C*, the bee can open this along its whole ;th. This tube and also the sheath (*s*) connects through the ılar mentum (*m* in *A*) with the œsophagus, and so with the nach. Just at the base of the mentum, as shown in Fig. 2, ʻoduced from Mr. Justin Spaulding's paper in American Natu-



G. 1. *A*, *B*, *C*, Tongue of the Honey Bee.

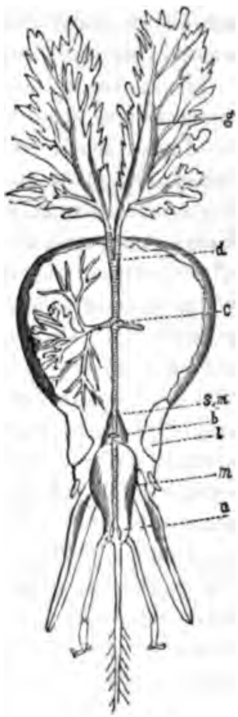


FIG. 2. Tongue of the Honey Bee.

ıt, vol. 15, page 113, this tube receives the tube from four e compound racemose glands, two of which are in the head the others are in the thorax.

ʳe see, then, that secretions from these glands may be poured the tube of the central rod, or into the tubular sheath. The ılar rod opens at the tip of the ligula (*f* in *A*), but the tubular ıth is imperforate except at its base, where it joins the tube of mentum, and so has connection with the duct of the glands,

with the œsophagus, the mouth and the tube of the central rod. When the mouth-organs are not in use, the tip of the ligula, *f* in *A*, extends only to the tip of the labial palpi, *K*, *K* in *A*, and all the parts, *t*, *K*, *K*, and *mx*, *mx* in *A*, are doubled back under the head. By the action of several pairs of muscles, variously attached to these parts and to the head, these parts are straightened, preparatory to use; then by the injection of liquid into the tubular sheath, the ligula is fully protruded. By holding a bee between the fingers (a bumble bee is the best), we can see the tongue vary in size as it is protruded or retracted as we offer it sweets. Of course, a good lens is necessary in this demonstration.

The source of the liquid that extends the tongue is, I think, that which comes from the glands already mentioned. If we take a dead bee that is not rigid, and whose sucking-stomach is full of honey, and press on the abdomen, the nectar will come forth from the mouth-opening, and not from the end of the ligula. The sheath does not expand, and of course the ligula is not pushed out. But if we press on the mentum, either when the stomach is empty or when it is full, then the sheath is distended, and the tongue is pushed out. In thus pressing the mentum of a bumble bee till the sheath was burst open, I have found that the liquid that came forth was often entirely without sweet taste. Therefore, unless it came from the salivary glands, it must have come from the glands described above. It is hardly supposable that the mucus from the tube would be sufficient. Again, it is just as necessary for the tongue to be thrust out — yes, and more necessary — when the sucking-stomach is empty, as when it is full. But if nectar from the stomach is what is used, how would the bee extend the tongue when the sucking-stomach was empty? The enlarged ducts from the glands would, on the other hand, always have the material ready to effect this important purpose.

It has been suggested that the secretion from these glands is used to change the nectar into honey, or in case the bees are fed cane sugar, to change a part of the cane sugar to grape sugar. That such a change is brought about is certain, but it is done in the stomach, and if the secretions referred to perform this function, they must be carried down with the honey. Thus, they would perform two functions, one a physical, and the other a chemical. This is thought to be true of our own saliva, by many physiologists. It certainly aids in comminuting the food, and many think that it aids in transforming the starch of the food into grape sugar.

ON A CERTAIN HABIT OF HELICONIA CHARITONIA. By W. H. EDWARDS, of Coalburg, W. Va.

[ABSTRACT.]

MR. EDWARDS gave an account of a peculiar habit of Heliconia charitonia, Linn., as observed and communicated by Dr. Wm. Wittfield, of Indian River, Fla. In two instances a group of the butterflies of this species, three or four in number, were found clinging by their legs firmly to a chrysalis of the same species, and they remained there, resisting attempts to frighten them away, for two days or more, until the imago issued from the chrysalis, when the butterflies departed.

TITLES OF OTHER PAPERS READ BEFORE THE SUB-SECTION OF ENTOMOLOGY.[1]

CARBOLIC ACID AS A PREVENTIVE OF INSECT RAVAGES. By A. J. Cook, of Lansing, Mich.

ON THE LENGTH OF LIFE OF BUTTERFLIES.[2] By W. H. Edwards, of Coalburg, W. Va.

AN ALLEGED ABNORMAL PECULIARITY IN THE HISTORY OF ARGYNNIS MYRINA.[3] By W. H. Edwards, of Coalburg, W. Va.

SUGGESTIONS OF COÖPERATION IN FURTHERING THE STUDY OF ENTOMOLOGY. By B. Pickman Mann, of Cambridge, Mass.

THE EGG-CASE OF HYDROPHILUS TRIANGULARIS. By C. V. Riley, of Washington, D. C.

THE COCOON OF GYRINUS. By C. V. Riley, of Washington, D. C.

[1] A full report of the Entomological Section is given in the CANADIAN ENTOMOLOGIST for Sept. and Oct., 1881, and the several papers mentioned in this list of titles are printed there either in full or by abstract. The AMERICAN NATURALIST for November and December, and PAPILIO for September also contain a report of the meetings of the Section and some of the papers read before it.

[2] Printed in full in CANADIAN ENTOMOLOGIST for October, 1881.

[3] Printed in full in PAPILIO, September, 1881.

PERMANENT

SUBSECTION OF ANTHROPOLOGY.

ADDRESS

BY

COL. GARRICK MALLERY, U. S. A.

CHAIRMAN OF SUBSECTION OF ANTHROPOLOGY.

THE GESTURE SPEECH OF MAN.

ANTHROPOLOGY tells the march of mankind out of savagery. In that march some peoples have led with the fleet course of videttes or the sturdy stride of pioneers, some have only plodded on the roads opened by the vanguard, while others still lag in the unordered rear, mere dragweights to the column. All commenced their progress toward civilization from a point of departure lower than the stage reached by the lowest of the tribes now found on earth, and all, even the most advanced, have retained marks of their rude origin. These marks are of the same kind, though differing in distinctness, and careful search discovers the fact that none are missing, showing that there is a common source to all the forms of intellectual and social development, notwithstanding their present diversities. Perhaps the most notable criterion of difference is in the copiousness and precision of oral language, and in the unequal survival of the communication by gesture signs which, it is believed, once universally prevailed. The phenomena of that mode of human utterance, wherever it still appears, require examination as an instructive vestige of the prehistoric epoch. In this respect the preëminent gesture system of the North American Indians calls for study in comparison with other less developed or more degenerate systems. It may solve problems in psychologic comparative philology not limited to the single form of speech, but embracing all modes of expressing ideas. Perhaps, therefore, a condensed report of such study pur-

sued with advantages possessed by few persons even in this country will, on this occasion, be an acceptable contribution as illustrating the gesture speech of man.

So far as the use of gesture signs continued, however originating, in the necessity for communication between peoples of different oral speech, North America shows more favorable conditions for its development than any other thoroughly explored part of the world. In that great continent the precolumbian population was, as is now believed, scanty, and so subdivided dialectically, that the members of but few bands could readily converse with others. The number of now defined stocks or families of Indian languages within the territory of the United States amounts to sixty-five, and these differ among themselves as radically as each differs from the Hebrew, Chinese, or English. In each of these linguistic families there are several, sometimes as many as twenty, separate languages, which also differ from each other as much as do the English, French, German and Persian divisions of the Aryan linguistic stock.

The conditions upon which the survival of sign language among the Indians has depended are well shown by those attending its discontinuance among certain tribes. The growth of the mongrel tongue, called the Chinook jargon, arising from the same causes that produced the pigeon-English, or *lingua franca* of the Orient, explains the known recent disuse of systematic signs among the Kalapuyas and other tribes of the North Pacific coast. The Alaskan tribes also generally used signs not more than a generation ago. Before the advent of the Russians the coast Alaskans traded their dried fish and oil for the skins and paints of the eastern tribes by visiting the latter, whom they did not allow to come to the coast, and this trade was conducted mainly in sign language. The Russians brought a better market, so the travel to the interior ceased, and with it the necessity for the signs, which therefore gradually died out, and are little known to the present generation on the coast, though still continuing in the interior where the inhabitants are divided by dialects.

No explanation is needed for the gradual disuse of signs for the special purpose of intertribal communication when the speech of surrounding civilization becomes known as the best common medium. When that has become general, and there is a compelled end both to hunting and warfare, signs, as systematically employed

efore, fade away, or survive only in formal oratory and impassioned conversation.

THEORIES ENTERTAINED RESPECTING INDIAN SIGNS.

It is not now proposed to pronounce upon theories. The mere ollection of facts cannot, however, be prosecuted to advantage vithout predetermined rules of direction, nor can they be classiied at all without the adoption of some principle which involves . tentative theory. Now, also, since the great principle of evoution has been brought to general notice, no one will be satisfied vith knowing a fact without also trying to establish its relation to ther facts. Therefore a working hypothesis, which shall not be ıeld to with tenacity, is not only allowable but necessary. It is ikewise proper to examine with respect the theories advanced by others.

NOT CORRELATED WITH MEAGERNESS OF LANGUAGE.

The ever unconfirmed report of travellers that certain languages cannot be clearly understood in the dark by their possessors, using their mother tongue between themselves, when asserted, as it often has been, in reference to any of the tribes of North America, is absolutely false. It must be attributed to the error of visitors, who seldom see the natives except when trying to make themselves intelligible to them by a practice which they have found by experience to have been successful with strangers to their tongue. Captain Burton specially states that the Arapahos possess a very scanty vocabulary, pronounced in a quasi-unintelligible way, and can hardly converse with one another in the dark. The truth is that their vocabulary is by no means scanty, and they do converse with each other with perfect freedom without any gestures when they so please. The same distinguished explorer also gives a story "of a man who, being sent among the Cheyennes to qualify himself for interpreting, returned in a week and proved his competency; all he did, however, was to go through the usual pantomine with a running accompaniment of grunts." And he might as well have omitted the grunts, for obviously he only used sign language.

The similar accusation made against the Shoshonian stock, that their tongue, without signs, was too meager for understanding, is refuted by my own experience. When Ouray, the late head chief of the Utes, was last at Washington, after an interview with the

Secretary of the Interior, he made report of it to the others of the delegation who had not been present. He spoke without pause in his own language for nearly an hour, in a monotone and without a single gesture. The reason for this depressed manner was undoubtedly because he was very sad at the result, involving loss of land and change of home; but the fact remains that full information was communicated on a complicated subject without the aid of a manual sign, and also without even such change of inflection of voice as is common among Europeans. All theories based upon the supposed poverty of American languages must be abandoned.

The grievous accusation against foreign people that they have no intelligible language is venerable and general. With the Greeks the term ἄγλωσσος, "tongueless," was used synonymous with βάρβαρος, "barbarian," of all who were not Greek. The name "Slav," assumed by a grand division of the Aryan family, means "the speaker," and is contradistinguished from the other peoples of the world, such as the Germans, who are called in Russian "Njemez," that is, "speechless." In Isaiah (xxxiii, 19) the Assyrians are called a people "of a stammering tongue, that one cannot understand." The common use of the expressions "tongueless" and "speechless," so applied, has probably given rise to the mythical stories of actually speechless tribes of savages, and the instances now presented tend to discredit the many other accounts of languages which are incomplete without the help of gesture. The theory that sign language was in whole or in chief the original utterance of mankind would be strongly supported by conclusive evidence to the truth of such travellers' tales, but does not depend upon them. Nor, considering the immeasurable period during which, in accordance with modern geologic views, man has been on the earth, is it probable that any existing peoples can be found among whom speech has not obviated the absolute necessity for gesture in communication between themselves. The signs survive for convenience, used together with oral language, and for special employment when language is unavailable.

ITS ORIGIN FROM ONE TRIBE OR REGION.

My correspondents in the Indian country have often contended that sign language was invented by a certain tribe in a particular region from which its knowledge spread among other tribes in-

versely as their distance from, and directly as their intercourse with, the alleged inventors. Unfortunately there is no agreement as to the latter, and probably the accident that the several correspondents met, in certain tribes, specially skilful sign-talkers, letermined their opinions. The theory also supposes a comparaively recent origin of sign language, whereas so far as can be raced, the conditions favorable to it existed very long ago and rere coëxtensive with the territory of North America occupied by .ny of the tribes. Some writers confine its use to the Great Plains. It is, however, ascertained to have prevailed among the roquois, Wyandots, Ojibwas, and at least three generations back among the Crees and the Mandans and other far northern Dakotas. Some of these and many other tribes of the United States never habiting the Plains, as also the Kutchins of eastern Alaska and the Kutine and Selish of British Columbia, use signs now. Instead of referring to some past period when they did not use signs, many Indians examined speak of a time when they or heir fathers employed them more freely and copiously than at present.

Perhaps the most salutary criticism to be offered regarding the theory would be in the form of a query whether sign language has ever been invented by any one body of people at any one time, and whether it is not simply a phase in evolution, surviving and reviving when needed. Not only does the burden of proof rest unfavorably upon the attempt to establish one parent stock for sign language in North America, but it also comes under the stigma now fastened upon the immemorial effort to name and locate the original oral speech of man. It is only next in difficulty to the old persistent determination to decide upon the origin of the whole Indian "race," in which most peoples of antiquity in the eastern hemisphere, including the lost tribes of Israel, the Gipsies, and the Welsh, have figured conspicuously as putative parents.

SIGN LANGUAGE NOT UNIFORM.

The general report that there is but one sign language in North America, any deviation from which is either blunder, corruption, or a dialect in the nature of provincialism, originated with sign talkers in several regions. Now a mere sign talker is often a bad authority upon principles and theories. He may not be

liable to the satirical compliment of Dickens' "brave courier," who "understood all languages indifferently ill;" but many men speak some one language fluently, and yet are wholly unable to explain or analyze its words and forms so as to teach it to another, or even to give an intelligent summary or classification of their own knowledge. What such a sign talker has learned is by memorizing, as a child learns English, and though both the sign talker and the child may be able to give some separate items useful to a philologist or foreigner, such items are spoiled when colored by the attempt of ignorance to theorize. A German who has studied English to thorough mastery, except in the mere facility of speech, may in a discussion upon some of its principles be contradicted by any mere English speaker, who insists upon his superior knowledge because he actually speaks the language and his antagonist does not, but the student will probably be correct and the talker wrong. It is an old adage about oral speech that a man who understands but one language understands none. The science of a sign talker possessed by a restrictive theory is like that of Mirabeau, who was greater as an orator than as a philologist, and who on a visit to England gravely argued that there was something seriously wrong in the British mind because the people would persist in saying "give me some bread" instead of "*donnez-moi du pain*," which was so much easier and more natural. When a sign is presented which such a sign talker has not before seen, he will at once condemn it as bad, just as a United States Minister to Vienna, who had been nursed in the mongrel Dutch of Berks County, Pennsylvania, declared that the people of Germany spoke very bad German.

An argument for the uniformity of the signs of Indians is derived from the fact that those used by any of them are generally understood by others. But signs may be understood without being identical with any before seen. It is a common experience that when Indians find a sign which has become conventional among their tribe not to be understood by an interlocutor, a self expressive sign is substituted for it, from which a visitor may form the impression that there are no conventional signs. It may likewise occur that the self-expressive sign substituted will be met with by a visitor in several localities, different Indians, in their ingenuity, taking the best and the same means of reaching the exotic intelligence.

There is some evidence that where sign language is now found among Indian tribes it has become more uniform than ever before, simply because many tribes have for some time past been forced to dwell near together at peace. The resulting uniformity in these cases might either be considered as a jargon or as the natural tendency to a compromise for mutual understanding—the unification so often observed in oral speech coming under many circumstances out of former heterogeneity. The rule is that dialects precede languages and that out of many dialects comes one language.

The process of the formation and introduction of signs is the same among Indians as often observed among deaf-mutes. When a number of those unfortunate persons, possessed only of such crude signs as were used by each among his speaking relatives come together for a considerable time, they are at first only able to communicate on a few subjects, but the number of those and the general scope of expression will be continually enlarged. Each one commences with his own conception and his own presentment of it, but the universality of the medium used makes it sooner or later understood. This independent development often renders the first interchange of thought between strangers slow, for the signs must be self-interpreting. There can be no natural universal language which is absolute and arbitrary. When used without convention, as sign language alone of all modes of utterance can be, it must be tentative, experimental, and flexible. The mutes will also resort to the invention of new signs for new ideas as they arise, which will be made intelligible, if necessary, through the illustration and definition given by signs formerly adopted. The fittest signs will in due course be evolved, after rivalry and trial, and will survive. But there may not always be such a preponderance of fitness that all but one of the rival signs shall die out, and some being equal in value to express the same idea or object, will continue to be used indifferently, or as a matter of individual taste, without confusion. A multiplication of the numbers confined together, either of deaf-mutes or of Indians whose speech is diverse, will not decrease the resulting uniformity, though it will increase both the copiousness and the precision of the vocabulary. The Indian use of signs, though maintained by linguistic diversities, is not coincident with any linguistic boundaries. The tendency is to their uniformity among groups

of people who from any cause are brought into contact with each other while still speaking different languages. The longer and closer such contact, while no common tongue is adopted, the greater will be the uniformity of signs.

Some writers take a middle ground with regard to the identity of the sign language of the North American Indians, comparing it with the dialects and provincialisms of the English language, as spoken in England, Ireland, Scotland and Wales.

But those dialects are the remains of actually diverse languages, which to some speakers have not become integrated. In England alone the provincial dialects are traceable as the legacies of Saxons, Angles, Jutes, and Danes, with a varying amount of Norman influence. A thorough scholar in the composite tongue, now called English, will be able to understand all the dialects and provincialisms of English in the British Isles, but the uneducated man of Yorkshire is not able to communicate readily with the equally uneducated man of Somersetshire. This is the true distinction. A thorough sign talker would be able to to talk with several Indians who have no signs in common, and who, if their knowledge of signs were only memorized, could not communicate with each other. So, also, as an educated Englishman will understand the attempts of a foreigner to speak in very imperfect and broken English, a good Indian sign-expert will apprehend the feeblest efforts of a tyro in gestures. But the inference that there is but one true Indian sign language, just as there is but one true English language, is not correct unless it can be shown that a much larger proportion of the Indians who use signs at all, than present researches show to be the case, use identically the same signs to express the same ideas. It would also seem necessary to the parallel that the signs so used should be absolute, if not arbitrary, as are the words of an oral language, and not independent of preconcert and self-interpreting at the instant of their invention or first exhibition, as all true signs must originally have been and still measurably remain.

ARE SIGNS CONVENTIONAL OR INSTINCTIVE?

There has been much discussion on the question whether gesture signs were originally invented, in the strict sense of that term, or whether they result from a natural connection between

hem and the ideas represented by them, that is, whether they re conventional or instinctive. Cardinal Wiseman (*Essays*, III, 37) thinks they are of both characters; but referring particularly o the Italian signs and the proper mode of discovering their neaning, he observes that they are used primarily with words and orm the usual accompaniment of certain phrases. "For these he gestures become substitutes, and then by association express ll their meaning, even when used alone." This would be the rocess only where systematic gestures had never prevailed or ad been so disused as to be forgotten, aud were adopted after laborate oral phrases and traditional oral expressions had be- ome common. Sign language as a product of evolution has een developed rather than invented, and yet it seems probable hat each of the separate signs, like the several steps that lead o any true invention, had a definite origin arising out of some ppropriate occasion, and the same sign may in this manner have ad many independent origins due to identity in the circum- tances, or, if lost, may have been reproduced.

Another form of the query is whether signs are arbitrary or atural. An unphilosophic answer will often be made in ac- ordance with what the observer considers to be natural to him- elf. A common sign among both deaf-mutes and Indians for *woman* consists in designating the arrangement of the hair, but uch a represented arrangement of hair familiar to the gesturer s had never been seen by the person addressed would not seem natural" to the latter. It would be classed as arbitrary, and ould not be understood without context or explanation, indeed ithout translation such as is required from foreign oral speech. igns most naturally, that is appropriately, expressing a con- eption of the thing signified, are first adopted from circumstances f environment, and afterwards modified so as to appear, with- ut full understanding, conventional and arbitrary, yet they are as ruly "natural" as the signs for hearing, seeing, eating, and rinking, which continue all over the world as they were first ormed because there is no change in those operations.

Perhaps no signs in common use are in their origin conven- ional. What appears to be conventionality largely consists in he form of abbreviation which is agreed upon. When the signs f the Indians have from ideographic form become demotic hey may be roughly called conventional, but still not arbitrary.

SOME NATURAL SIGNS CONVENTIONALIZED.

But while all Indians, as all gesturing men, have many natural signs in common, they use many others which have become conventional in the sense that their origin and conception are not now known or regarded by the persons using them. The conventions by which the latter were established occurred during long periods, when the tribes forming them were so separated as to have established altogether diverse customs and mythologies, and when the several tribes were exposed to such different environments as to have formed varying conceptions needing appropriate sign expression. The old error that the North American Indians constitute one homogeneous race is now abandoned. Nearly all the characteristics once alleged as segregating them from the rest of mankind have proved not to belong to the whole of the precolumbian population, but only to those portions of it first explored. The practice of scalping is not now universal, if it ever was, even among the tribes least influenced by civilization, and therefore the cultivation of the scalp-lock separated from the rest of the hair of the head, or with the removal of all other hair, is not a general feature of their appearance. The arrangement of the hair is so different among tribes as to be one of the most convenient modes for their pictorial distinction. The war paint, red in some tribes, was black in others; the mystic rites of the calumet were in many regions unknown, and the use of wampum was by no means extensive. The wigwam is not the type of native dwellings, which show as many differing forms as those of Europe. In color there is a great variety, and even admitting that the term "race" is properly applied, no competent observer would characterize it as red, still less copper-colored. Some tribes differ from each other in all respects nearly as much as either of them do from the lazzaroni of Naples, and more than either do from certain tribes of Australia. It would therefore be expected, as is the case, that the conventional signs of different stocks and regions differ as do the words of English, French and German, which, nevertheless, have sprung from the same linguistic roots. No one of those languages is a dialect of any of the others; and although the sign systems of the several tribes have greater generic unity with less specific variety than oral languages, no one of them is necessarily the dialect of any other. To insist that sign language is uniform

rere to assert that it is perfect — "That faultless monster that the rorld ne'er saw."

GENERAL ANCIENT USE OF THE SYSTEM IN N. A.

The supposition that the systematic use of signs once existed mong all Indian tribes receives support from the fact that in iearly all instances where such existence has been at first denied, urther research has discovered the remains, even if not the pracice, of sign language. This has been even among tribes long xposed to European influence and officially segregated from all others. Collections have been obtained from the Iroquois, Ojibras, Alaskans, Apaches, Zuñi, Pimas, Papagos and Maricopas, ifter army officers, missionaries, Indian agents and travellers had lenied them to be possessed of any knowledge on the subject.

One of the most interesting proofs of the general knowledge of ign language, even when seldom used, was given in the visit f five Jicarilla Apaches to Washington in April, 1880, under the iarge of their agent. The latter said he had never heard of any se of signs among them. But it happened that there was a delgation of Absaroka (Crows) at the same hotel, and the two pares, from regions one thousand miles apart, not knowing a word f each other's language, immediately began to converse in signs, esulting in a decided sensation. One of the Crows asked the paches whether they ate horses, and it happening that the sign or *eating* was misapprehended for that known by the Apaches for *nany*, the question was supposed to be whether the latter had nany horses, which was answered in the affirmative. Thence enued a misunderstanding on the subject of hippophagy, which was urious both as showing the general use of signs as a practice and he diversity in special signs for particular meanings. The surrise of the agent at the unsuspected accomplishment of his harges was not unlike that of a hen which, having hatched a iumber of duck eggs, is perplexed at the instinct with which the rood takes to the water.

The denial of the use of signs is sometimes faithfully though rroneously reported from the distinct statements of Indians to hat effect. In that, as in other matters, they are often provokngly reticent about their old habits and traditions. Chief Ouray sserted to me, that his people, the Utes, had not the practice of

sign talk, and had no use for it. This was much in the proud spirit in which an Englishman would have made the same statement, as the idea involved an accusation against the civilization of his people, whom he wished to appear highly advanced. Within the same week I took seven Utes, members of the delegation then with Ouray, to the National Deaf-Mute College, and they showed not only perfect familiarity with, but expertness in, signs.

The studies thus far pursued lead to the conclusion that at the time of the discovery of North America all its inhabitants practised sign language, though with different degrees of expertness; and that, while under changed circumstances, it was disused by some, others, especially those who after the acquisition of horses became nomads of the Great Plains, retained and cultivated it to the high development now attained.

PERMANENCE OF SIGNS.

It is important to inquire into the permanence of particular gesture signs to express a special idea or object when the system has been long continued. The gestures of classic times are still in use by the modern Italians with the same signification; indeed the former, on Greek vases or reliefs, or in Herculanean bronzes, can only be interpreted by the latter. In regard to the signs of instructed deaf-mutes in this country there appears to be a permanence beyond expectation. A pupil of the Hartford Institute half a century ago lately stated that the signs used by teachers and pupils at Hartford, Philadelphia, Washington, Council Bluffs and Omaha, were nearly the same as he had learned. "We still adhere to the old sign for President from Monroe's three-cornered hat, and for governor we designate the cockade worn by that dignitary on grand occasions three generations ago."

Specific comparisons made of the signs reported by the Prince of Wied, in 1832, with those now used by the same tribes from whom he obtained them, show a remarkable degree of permanence. If they have persisted for half a century their age is probably much greater. In general it is believed that signs, constituting as they do a natural mode of expression, though enlarging in scope as new ideas and new objects require to be included and though abbreviated variously, do not readily change in their essentials.

I do not present any Indian signs as precisely those of primitive man, not being so carried away by enthusiasm as to suppose them possessed of immutability and immortality not found in any other mode of human utterance. Signs as well as words, animals, and plants have had their growth, development and change, their births and deaths, and their struggle for existence with survival of the fittest. Yet when signs, which are general among Indian tribes, are also prevalent in other parts of the world, they probably are of great antiquity. The use of derivative meanings to a sign only enhances this presumption. At first there might not appear to be any connection between the ideas of *same* and *wife*, expressed by the sign of horizontally extending the two forefingers side by side. The original idea was doubtless that given by the Welsh captain in Shakspere's Henry V: "'Tis so like as my fingers is to my fingers;" and from this similarity comes "equal," "companion," and subsequently the close life-companion "wife." The sign is used in each of these senses by different Indian tribes, and sometimes the same tribe applies it in all of the senses as the context determines. It appears also in many lands with all the significations except that of "wife."

Many signs but little differentiated were unstable, while others that have proved the best modes of expression have survived as definite and established. A note may be made in this connection of the large number of diverse signs for *horse*, all of which must have been invented within a comparatively recent period, and the small variation in the signs for *dog*, which are probably ancient.

IS THE INDIAN SYSTEM SPECIAL AND PECULIAR?

While denying the uniformity of Indian signs, it is proper to inquire whether their system, as a whole, is special and peculiar to themselves. This may be determined by comparing that system with those of other peoples and of deaf-mutes.

COMPARISONS WITH FOREIGN SIGNS.

My researches during several years show a surprising number of signs for the same idea which are substantially identical, not only among savage tribes, but among all peoples that use gesture

signs with any freedom. Men, in groping for a mode of communication with each other, and using the same general methods, have been under many varying conditions and circumstances which have determined differently many conceptions and their semiotic execution, but there have also been many of both which were similar. North American Indians have no special superstition concerning the evil-eye like the Italians, nor have they been long familiar with the jackass so as to make him, with more or less propriety, emblematic of stupidity; therefore signs for those concepts are not cisatlantic, but many are substantially in common between our Indians and Italians. Many other Indian signs are identical, not only with those of the Italians and the classic Greeks and Romans, but of other peoples of the Old World, both savage and civilized. The generic uniformity is obvious, while the occasion of specific varieties can be readily understood.

The same remark applies to the collections of signs already obtained by correspondence from among the Turks, Armenians and Koords, the Bushmen of Africa, the Fijians, the Redjangs and Lelongs of Sumatra, the Chinese and the Australians. The results of researches in Ceylon, India, South America and several other parts of the world, are not yet sufficient to allow of their classification. Much interesting material is expected from inquiries recently instituted through the medium of Mr. Hyde Clarke, Vice President of the Anthropological Institute of Great Britain and Ireland, into the sign language of the mutes of the Seraglio at Constantinople. That they had a system of communication was noticed by Sibscota, in 1670, without his giving any details. It appears not only to be known to the inmates themselves, but to high officials, eunuchs and other persons connected with the Sublime Porte. As it is supposed that the Osmanli Sultans followed the Byzantine emperors in the employment of mutes, and that they adopted them from Persian kings, it is possible that the signs, now in systematic, though limited, use, have been regularly transmitted from high oriental antiquity.

COMPARISON WITH DEAF-MUTE SIGNS.

The Indians who have been brought to the eastern states have often held happy intercourse by signs with white deaf-mutes, who surely have no semiotic code preconcerted with any of the plain-

-oamers. While many of their signs were identical, and all sooner or later were mutually understood, it has been noticed that the signs of the deaf-mutes were more readily understood by the Indians than were theirs by the deaf-mutes, and that the latter greatly excelled in pantomimic effect. What is to the Indian a mere adjunct or accomplishment is to the deaf-mute the natural mode of utterance. The "action, action, action," of Demosthenes is their only oratory, not mere heightening of it, however valuable.

The result of the comparisons is that the so-called sign language of Indians is not properly speaking one language, but that it and the gesture systems of deaf-mutes and of all peoples constitute together one language — the gesture speech of mankind — of which each system is a dialect.

GESTURES AIDING ARCHÆOLOGICAL RESEARCH.

The most interesting light in which the Indians of North America can be regarded is in their present representation of a stage of evolution once passed through by our own ancestors. Their signs, as well as their myths and customs, form a part of the palæontology of humanity to be studied in the history of the latter, as the geologist, with similar object, studies all the strata of the physical world. At this time it is only possible to state that gesture signs have been applied to elucidate pictographs, and also to discover religious, sociologic, and historic ideas preserved in themselves, as has been done with great success in the radicals of oral speech.

SIGNS CONNECTED WITH PICTOGRAPHS.

The picture writing of Indians is the sole form in which they recorded events and ideas that can ever be interpreted without the aid of a traditional key, such as is required for the signification of the wampum belts of the northeastern tribes and the *quippus* of Peru. Strips of bark, tablets of wood, dressed skins of animals, and the smooth surfaces of rocks have been and still are used for such records, those most ancient, and therefore most interesting, being the rock etchings; but they can only be deciphered by the ascertained principles on which the more modern and obvious are made. Many of the widespread rock carvings

are mere idle sketches of natural objects, mainly animals, and others are as strictly mnemonic as is the wampum. But where there has existed a rude form of graphic representation, and at the same time a system of ideographic gesture signs prevailed, it would be expected that the form of the latter would appear in the former. That this is the fact among North American Indians will be shown in a paper to be read before the section by my collaborator Dr. W. J. Hoffman, and at greater length in a report by myself to form part of the first Annual Report of the Bureau of Ethnology, now in press. This fact is of great archæologic importance, as the reproduction of gesture lines in the pictographs made by Indians has, for obvious reasons, been most frequent in the attempt to convey those subjective ideas which were beyond the range of an artistic skill limited to the direct representation of objects, so that the part of the pictographs which is the most difficult of interpretation is the one which the study of sign language can elucidate. Traces of the same signs used by Indians found in the ideographic pictures of the Egyptians, and in Chinese and Aztec characters, are also exhibited by illustrations in the Report above mentioned.

HISTORY OF GESTURE LANGUAGE.

There is ample evidence of record, besides that derived from other sources, that the systematic use of gesture speech was of great antiquity. Livy so declared, and Quintilian specifies that the "*lex gestus * * * ab illis temporibus heroicis orta est.*" Athenæus tells that gestures were reduced to distinct classification with appropriate terminology. One of these classes was adapted by Bathyllus to pantomime.

While the general effect of the classic pantomimes is often mentioned, there remain but few detailed descriptions of them. Apuleius, however, in his *Metamorphosis* gives sufficient details of the performance of the Judgment of Paris to show that it resembled the best form of modern ballet opera. The popularity of these exhibitions continued until the sixth century, and it is evident from a decree of Charlemagne that they were not lost, or, at least, had been revived in his time. Those of us who have enjoyed the performance of the original Ravel troupe will admit that the art still survives, though not with the magnificence or perfection,

especially with reference to serious subjects, which it exhibited in the age of imperial Rome.

Quintilian gave most elaborate rules for gestures in oratory, which are specially noticeable from the importance attached to the manner of disposing the fingers. He attributed to each particular disposition a significance or suitableness which is not now obvious. The value of these digital arrangements is, however, exhibited by their use among the modern Italians, to whom they have directly descended. Their curious elaboration appears in the volume by the canon Andrea de Jorio, *La Mimica degli Antichi investigata nel Gestire Napoletano, Napoli*, 1832. The canon's chief object was to interpret the gestures of the ancients as exhibited in their works of art and described in their writings, by the modern gesticulations of the Neapolitans, and he has shown that the general system of gesture once prevailing in ancient Italy is substantially the same as now observed. With an understanding of the existing language of gesture the scenes on the most ancient Greek vases and reliefs obtain a new and interesting significance and form a connecting link between the present and prehistoric times.

USE BY MODERN ACTORS.

Less of practical value can be learned of sign language, considered as a system, from the study of the gestures used by actors, than would appear without reflection. The pantomimist, indeed, who uses no words whatever, is obliged to avail himself of every natural or imagined connection between thought and gesture, and depending wholly upon the latter, makes himself intelligible. With speaking actors, however, words are the main reliance, and gestures generally serve for rhythmic movement and to display personal grace.

When many admirers of Ristori, who were wholly unacquainted with the language in which her words were delivered, declared that her gesture and expression were so perfect that they understood every sentence, it is to be doubted if they would have been so delighted if they had not been thoroughly familiar with the plots of Queen Elizabeth and Mary Stuart. This view is confirmed by the case of a deaf-mute, known to me, who had prepared to enjoy Ristori's acting by reading in advance the advertised play,

but on his reaching the theatre another play was substituted and he could derive no idea from its presentation. A crucial test on this subject was made at the representation at Washington last April, of *Frou-Frou* by Sara Bernhardt and the excellent French company supporting her. Several persons of special intelligence and familiar with theatrical performances, but who did not understand spoken French, and had not heard or read the play or even seen an abstract of it, paid close attention to ascertain what they could learn of the plot and incidents from the gestures alone. This could be determined in the special play the more certainly as it is not founded on historic events or any known facts. The result was that from the entrance of the heroine during the first scene in a peacock-blue riding habit to her death in a black walking-suit, three hours or five acts later, none of the students formed any distinct conception of the plot. This want of apprehension extended even to uncertainty whether *Gilberte* was married or not; that is, whether her adventures were those of a disobedient daughter or a faithless wife, and, if married, which of the half dozen male personages was her husband. There were gestures enough, indeed rather a profusion of them, and they were thoroughly appropriate to the words (when those were understood) in which fun, distress, rage, and other emotions were expressed, but in no cases did they interpret the motive for those emotions. They were the dressing for the words of the actors as the superb millinery was that of their persons, and perhaps acted as varnish to bring out dialogues and soliloquies in heightened effect. But though varnish can bring into plainer view dull or faded characters, it cannot introduce into them significance where none before existed. The simple fact was that the gestures of the most famed histrionic school, the Comédie Française, were not significant, far less self-interpreting, and though praised as the perfection of art, have diverged widely from nature.

However numerous and correct may be the actually significant gestures made by a great actor in the representation of his part, they must be in small proportion to the number of gestures not at all significant, and which are no less necessary to give to his declamation precision, grace and force. Histrionic perfection is, indeed, more shown in the slight shades of movement of the head, glances of the eye, and poises of the body than in violent attitudes; but these slight movements are wholly unintelligible apart

from the words uttered with them. Even in the expression of strong emotion the same gesture will apply to many and utterly diverse conditions of fact. Its fitness consists in being the same which the hearer of the expository words would spontaneously assume if yielding to the same emotions, and which therefore by association tends to induce a sympathetic yielding. The greatest actor in telling that his father was dead can convey his grief with a shade of difference from that which he would use if saying that his wife had run away, his son been arrested for murder, or his house burned down; but that shade would not without words inform any person, ignorant of the supposed event, which of the four misfortunes had occurred. A true sign language, however, would fully express the exact circumstances, either with or without any exhibition of the general emotion appropriate to them.

Even among the best sign-talkers, whether Indian or deaf-mute, it is necessary to establish some *rapport* relating to theme or subject-matter, since many gestures, as indeed is the case in a less degree with spoken words, have widely different significations, according to the object of their exhibition, as well as the context. Rabelais (*Pantagruel*, Book III, ch. xiv) hits the truth upon this point, however ungallant in his application of it to the fair sex. Panurge is desirous to consult a dumb man, but says it would be useless to apply to a woman, for "whatever it be that they see they do always represent unto their fancies, and imagine that it hath some relation to love. Whatever signs, shows or gestures, we shall make, or whatever our behavior, carriage or demeanor, shall happen to be in their view and presence, they will interpret the whole in reference to androgynation." A story is told to the same point by Guevara, in his fabulous life of the Emperor Marcus Aurelius. A young Roman gentleman encountering at the foot of Mount Celion a beautiful Latin lady, who from her very cradle had been deaf and dumb, asked her in gesture what senators in her descent from the top of the hill she had met with, going up thither. She straightway imagined that he had fallen in love with her and was eloquently proposing marriage, whereupon she at once threw herself into his arms in acceptance. The experience of travellers of the Plains is to the same general effect, that signs commonly used to men are understood by women in a sense so different as to occasion embarrassment.

RESULTS SOUGHT IN THE STUDY OF SIGN LANGUAGE.

These may be divided into (1) its practical application, (2) its aid to philologic researches, and (3) its archæologic relations.

PRACTICAL APPLICATION.

The most obvious application of sign language will for its practical utility depend upon the correctness of the view submitted that it is not a mere semaphoric repetition of motions to be memorized from a limited traditional list, but is a cultivable art, founded upon principles which can be readily applied by travellers. This advantage is not merely theoretical, but has been demonstrated to be practical by a professor in a deaf mute college who, lately visiting several of the wild tribes of the plains, made himself understood among all of them without knowing a word of any of their languages, and by another who had a similar experience in Italy and southern France. It must, however be observed that the use of signs is only of great assistance in communicating with foreigners, whose speech is not understood, when both parties agree to cease all attempt at oral language, relying wholly upon gestures. So long as words are used at all, signs will be made only as their accompaniment, and they will not always be ideographic.

POWERS OF SIGNS COMPARED WITH SPEECH.

Sign language is superior to all others in that it permits every one to find in nature an image to express his thoughts on the most needful matters intelligibly to any other person. The direct or substantial natural analogy peculiar to it prevents a confusion of ideas. It is possible to use words without understanding them which yet may be understood by those addressed, but it is hardly possible to use signs without full comprehension of them. Separate words may be comprehended by persons hearing them without the whole connected sense of the words taken together being caught, but signs are more intimately connected. Even those most appropriate will not be understood if the subject is beyond

the comprehension of their beholders. They would be as unintelligible as the wild clicks of his instrument, in an electric storm, would be to the telegrapher, or as the semaphore, driven by wind, to the signalist. In oral speech even onomatopes are arbitrary, the most strictly natural sounds striking the ear of different individuals and nations in a manner wholly diverse. The instances given by Sayce are in point. Exactly the same sound was intended to be reproduced in the "*bilbit* amphora" of Nævius, the "*glut glut* murmurat unda sonans" of the Latin Anthology, and the "*puls*" of Varro. The Persian "*bulbul*," the "*jugjug*" of Gascoigne, and the "*whitwhit*" of others are all attempts at imitating the note of the nightingale. But successful signs must have a much closer analogy and establish a concord between the talkers far beyond that produced by the mere sound of words. The merely emotional sounds or interjections may be advantageously employed in connection with merely emotional gestures, but whether with or without them, they would be useless for the explicit communication of facts and opinions of which signs by themselves are capable. The combinations which can be made by signs are infinite and their enthusiastic teachers may be right in claiming that if they had been elaborated by the secular labor devoted to spoken language, man could, by his hands, arms and fingers, with facial and bodily accentuation, express any idea that could be conveyed by words. As, however, sign language has been chiefly used during historic time either as a scaffolding around a more valuable structure, to be thrown aside when the latter was completed, or as an occasional substitute, such development was not to be expected.

A comparison sometimes drawn between sign language and that of the North American Indians, founded on the statement of their common poverty in abstract expressions, is not just to either. Deeper study into Indian tongues has ascertained that they are by no means so confined to the concrete as was once believed, and the process of forming signs to express abstract ideas is only a variant from that of oral speech, in which the words for the most abstract ideas, such as law, virtue, infinitude, and immortality, are shown by Max Müller to have been derived and deduced, that is, abstracted, from sensuous impressions. This is done by selecting what is and rejecting what is not in common to the concrete ideas. Concepts of the intangible and invisible are only learned through

ecepts of tangible and visible objects, whether finally expressed , the eye or to the ear, in terms of sight or of sound. In the use f signs the countenance and manner as well as the tenor decide whether objects themselves are intended, or the forms, positions, qualities, and motions of other objects which are suggested; and signs for moral and intellectual ideas, founded on analogies, are common all over the world as well as among deaf-mutes. The very concepts of *plurality*, *momentum* and *righteousness*, selected by Tylor as the result of combined and compared thought which requires words, can be clearly expressed by signs, and it is not understood why those signs could not have attained their present abstract significance through the thoughts arising from the combination and comparison of other signs, without the actual intervention of words.

The elements of sign language are natural and universal, by recurring to which the less natural signs adopted dialectically or for expedition can always, with some circumlocution, be explained. This power of interpreting itself is a peculiar advantage over spoken languages, which, unless explained by gestures or indications, can only be interpreted by means of some other spoke language. When highly cultivated, its rapidity on familiar sub jects exceeds that of speech and approaches to that of though itself. This statement may be startling to those who do not con sider that oral speech is now wholly conventional, and that wit the similar development of sign language conventional expression with hands and body could be made more quickly than with th vocal organs, because more organs could be worked at once. At the same time it must be admitted that great increase in rapidi is chiefly obtained by a system of preconcerted abbreviations, a by the adoption of absolute forms, in which naturalness is sac ficed and conventionality established, as has been the case w all spoken languages in the degree in which they have beco copious and convenient.

There is another characteristic of the gesture speech th though it cannot be resorted to in the dark, nor where the atten of the person addressed has not been otherwise attracted has the countervailing benefit of use when the voice canno employed. This may be an advantage at a distance which t eye can reach, but not the ear, and still more frequently wh silence or secrecy is desired. Dalgarno recommends it for u

n the presence of great people, who ought not to be disturbed, nd curiously enough "Disappearing Mist," the Iroquois chief, peaks of the former extensive employment of signs in his tribe by omen and boys as a mark of respect to warriors and elders, heir voices, in the good old days, not being uplifted in the resence of the latter. The decay of that wholesome state of liscipline, he thinks, accounts partly for the disappearance of he use of signs among the modern impudent youth and the lusky claimants of woman's rights.

RELATIONS TO PHILOLOGY.

The aid to be derived from the study of sign language in prosecuting researches into the science of philology was pointed out by Leibnitz, in his *Collectanea Etymologica*, without hitherto exciting ny thorough or scientific work in that direction, the obstacle to it robably being that scholars competent in other respects had no dequate data of the gesture speech of man to be used in comarison. The latter will, it is hoped, be supplied by the work now ndertaken by me, under the direction of the Bureau of Ethnology, hich extends to the collection and collation of signs from all arts of the world as well as those of North American Indians.

It is generally admitted that signs played an important part n giving meaning to spoken words, and that many primordial oots of language have been founded in the involuntary sounds ccompanying certain actions. As, however, the action was the ssential, and the concomitant or consequent sound the accident, t would be expected that a representation or feigned reproluction of the action would have been used to express the idea efore the sound associated with that action would have been eparated from it. Philology, therefore, comparing the languages f earth in their radicals, must henceforth include the graphic r manual presentation of thought, and compare the elements f ideography with those of phonics. Etymology now examines the ultimate roots, not the fanciful resemblances between oral forms, in the different tongues; the internal, not the mere external parts of language. A marked peculiarity of sign language consists in its limited number of radicals and the infinite combinations into which those radicals enter while still remaining

istinctive. It is therefore a proper field for etymologic study.

It is possible to ascertain the included gesture even in many English words. The class represented by the word *supercilious* will occur to all, but one or two examples may be given not so obvious and more immediately connected with the gestures of Indians. *Imbecile*, generally applied to the weakness of old age, is derived from the Latin *in*, in the sense of on, and *bacillum*, a staff, which at once recalls the Cheyenne sign for *old man*, viz.: holding the right hand forward, bent at elbow with the fist closed sidewise, as if holding a staff. So *time* appears more nearly connected with the Greek τείνω, to stretch, when information is given of the sign for *long time*, viz.,: placing the thumbs and forefingers as if a small thread were held between the thumb and forefinger of each hand, the hands first touching each other, and then slowly moving apart, as if *stretching* a piece of gum-elastic.

Some special resemblances exist between the language of signs and the character of the oral languages found on this continent. Dr. J. Hammond Trumbull remarks of the composition of the words that they were "so constructed as to be thoroughly self-defining and immediately intelligible to the hearer." In another connection the remark is further enforced. "Indeed, it is a requirement of the Indian languages that every word shall be so framed as to admit of immediate resolution to its significant elements by the hearer. It must be thoroughly *self-defining*, for (as Max Müller has expressed it) 'it requires tradition, society, and literature to maintain words which can no longer be analyzed at once.' * * * In the ever-shifting state of a nomadic society no debased coin can be tolerated in language, no obscure legend accepted on trust. The metal must be pure and the legend distinct."

Indian languages, like those of higher development, sometimes exhibit changes of form by the permutation of vowels, but often an incorporated particle, whether suffix, affix, or infix, shows the etymology which often, also, exhibits the same objective conception that would be executed in gesture. There are, for instance, different forms for standing, sitting, lying, falling, and for standing, sitting, lying on or falling from the same level or a higher or lower level. This resembles the pictorial conception and execution of signs.

Indian languages exhibit the same fondness for demonstratio

which is necessary in sign language. The two forms of utterance are alike in their want of power to express certain words, such as the verb "to be," and in the criterion of organization, so far as concerns a high degree of synthesis and imperfect differentiation, they bear substantially the same relation to the English language.

It may be added that as not only proper names but nouns generally in Indian languages are connotive, predicating some attribute of the object, they can readily be expressed by gesture signs, and therefore among them, relations may be established between the words and the signs. Such have also been noticed, especially by my valued correspondent, Mr. Hyde Clarke, to exist between signs and the words of old Asiatic and African languages, showing the same operation of conditions in the same psychologic horizon.

DIVISIONS OF GESTURE SPEECH.

Gesture speech is composed of corporeal motion and facial expression. An attempt has been made by some writers to discuss these general divisions separately, and its success would be practically convenient if it were always understood that their connection is so intimate that they can never be altogether severed. A play of feature, whether instinctive or voluntary, accentuates and qualifies all motions intended to serve as signs, and strong instinctive facial expression is generally accompanied by action of the body or some of its members. But, so far as a distinction can be made, expressions of the features are the result of emotional, and corporeal gestures, of intellectual action. The former in general and the small number of the latter that are distinctively emotional are nearly identical among men from physiological causes which do not affect with the same similarity the processes of thought. The large number of corporeal gestures expressing intellectual operations require and admit of more variety and conventionality. Thus the features and the body among all mankind act almost uniformly in exhibiting fear, grief, surprise and shame, but all objective conceptions are varied and variously portrayed. Even such simple indications as those for "no" and "yes" appear in several different motions. While, therefore, the terms sign language and gesture speech necessarily include and suppose facial expression when emotions are in ques-

tion, they refer more particularly to corporeal motions and attitudes. For this reason much of the valuable contribution of Darwin in his *Expression of the Emotions in Man and Animals* is not directly applicable to sign language. His analysis of emotional gestures into those explained on the principles of serviceable associated habits, of antithesis, and of constitution of the nervous system, should, nevertheless, always be remembered. The earliest gestures were doubtless emotional, preceding those of a pictorial, metaphoric, and, still subsequent, conventional character.

THE ORIGIN OF SIGN LANGUAGE.

When examining into the origin of sign language through its connection with that of oral speech, it is necessary to be free from the vague popular impression that some oral language, of the general character of that now used among mankind, is "natural" to mankind. It will be admitted that all the higher oral languages were at some past time less opulent and comprehensive than they are now, and as each particular language has been thoroughly studied it has become evident that it grew out of some other and less advanced form.

Oral language consists of variations and mutations of vocal sounds produced as signs of thought and emotion. But it is not enough that those signs should be available as the vehicle of the producer's own thoughts. They must be also efficient for the communication of such thoughts to others. It has been, until of late years, generally held that thought was not possible without oral language, and that, as man was supposed to have possessed from the first the power of thought, he also from the first possessed and used oral language substantially as at present. That the latter, as a special faculty, formed the main distinction between man and the brutes, has been and still is the prevailing doctrine. It may, however, be doubted if there is any more necessary connection between ideas and sounds, the mere signs of thought that strike the ear, than there is between the same ideas and signs addressed only to the eye.

The point most debated for centuries has been, not whether there was any primitive oral language, but what that language was. Some literalists have indeed argued from the Mosaic nar-

itive that the primitive language had been taken away as a isciplinary punishment, as the Paradisiac Eden had been earlier ıst, and that, therefore, the search for it was as fruitless as to at- ımpt the passage of the flaming sword. More liberal Christians ıve been disposed to regard the Babel story as allegorical, if ɔt mythical, and have considered it to represent the disinte- ration of tongues out of one which was primitive. Though its ıest has led into error, it has, like those of the philosopher's one, of perpetual motion and of other phantasms in other di- ctions of thought, been of great indirect utility. It has stimu- ted philologic science, the advance of which has successively ıifted back the postulated primitive language from Hebrew to anscrit, thence to Aryan, and now it is attempted to evoke from ıe vasty deeps of antiquity the ghosts of other rival claimants ır precedence in dissolution.

The discussion is now, however, varied by the suggested possi- ility that man at some time may have existed without any oral nguage. It is of late conceded that mental images or represen- ıtions can be formed without any connection with sound, and may ; least serve for thought, if not for expression. It is certain that ɔncepts, however formed, can be expressed by other means than ɔund. One mode of this expression is by gesture, and there is ıss reason to believe that gestures commenced as the interpreta- on of or substitute for words, than that the latter originated in nd served to translate gestures. Many arguments have been ad- anced to prove that gesture language preceded articulate speech nd formed the earliest attempt at communication, resulting from ıe interacting subjective and objective conditions to which prim- ive man was exposed. Some of the facts on which deductions ave been based, made in accordance with well-established modes f scientific research from study of the lower animals, children, ıdividuals in mental disorder or isolated from their fellows, and ıe lower types of mankind, are of great interest, but it is only ɔssible now to examine those relating to deaf-mutes.

UNINSTRUCTED DEAF-MUTES.

The signs made by congenital and uninstructed deaf-mutes are ther those originating in or invented by individuals, or those of

a colloquial character used by such mutes where associated. The accidental or merely suggestive signs peculiar to families, one member of which happens to be a mute, are too much affected by the other members of the family to be of certain value. Those, again, which are taught in institutions have become conventional and were designedly adapted to translation into oral speech, although founded by the abbé de l'Épée, followed by the abbé Sicard, in the natural signs first above mentioned.

A great change has doubtless occurred in the estimation of congenital deaf-mutes since the Justinian Code which consigned them forever to legal infancy, as incapable of intelligence, and classed them with the insane. Yet most modern writers, for instance, Archbishop Whately and Max Müller, have declared that deaf-mutes could not think until after having been instructed. It cannot be denied that the deaf-mute thinks after his instruction either in the ordinary gesture signs or in the finger alphabet, or more lately in artificial speech. By this instruction he has become master of a highly-developed language, such as English or French, which he can read, write, and actually talk, but that foreign language he has obtained through the medium of signs. This is a conclusive proof that signs constitute a real language and one which admits of thought, for no one can learn a foreign language unless he had some language of his own, whether by descent or acquisition, by which it could be translated, and such translation into the new language could not even be commenced unless the mind had been already in action and intelligently using the original language for that purpose. In fact the use by deaf-mutes of signs originating in themselves exhibits a creative action of mind and innate faculty of expression beyond that of ordinary speakers who acquired language without conscious effort.

GESTURES OF FLUENT TALKERS.

The command of a copious vocabulary common to both speaker and hearer undoubtedly tends to a phlegmatic delivery and disdain of subsidiary aid. An excited speaker will, however, generally make a free use of his hands without regard to any effect of that use upon auditors. Even among the gesture-hating English, when they are aroused from torpidity of manner, the hands are involuntarily clapped in approbation, rubbed with delight, wrung

in distress, raised in astonishment, and waved in triumph. The fingers are snapped for contempt, the forefinger is vibrated to reprove or threaten, and the fist shaken in defiance. The brow is contracted with displeasure, and the eyes winked to show connivance. The shoulders are shrugged to express disbelief or repugnance, the eyebrows elevated with surprise, the lips bitten in vexation and thrust out in sullenness or displeasure. Quintilian becomes eloquent on the variety of motions of which the hands alone are capable.

"The action of the other parts of the body assists the speaker, but the hands speak themselves. By them do we not demand, promise, call, dismiss, threaten, supplicate, express abhorrence and terror, question and deny? Do we not by them express joy and sorrow, doubt, confession, repentance, measure, quantity, number, and time? Do they not also encourage, supplicate, restrain, convict, admire, respect?"

NATURAL PANTOMIME.

In the earliest part of man's history the subjects of his discourse must have been almost wholly sensuous, and therefore readily expressed in pantomime. Not only was pantomime sufficient for all the actual needs of his existence, but it is not easy to imagine how he could have used language such as is now known to us. If the best English dictionary and grammar had been miraculously furnished to him, together with the art of reading with proper pronunciation, the gift would have been valueless, because the ideas expressed by the words had not yet been formed.

That the early concepts were of a direct and material character is shown by what has been ascertained of the roots of language and there does not appear to be much difficulty in expressing by other than vocal instrumentality all that could have been expressed by those roots. Even now, with our vastly increased belongings of external life, avocations, and habits, nearly all that is absolutely necessary for our physical needs can be expressed in pantomime. Far beyond the mere signs for eating, drinking, sleeping, and the like, any one will understand a skilful representation in signs of a tailor, shoemaker, blacksmith, weaver, sailor, farmer, or doctor. So of washing, dressing, shaving, walking, driving, writing, reading, churning, milking, shoot-

ing, fishing, rowing, sailing, sawing, planing, boring, and, in short, an endless list.

Whether or not sight preceded hearing in order of development, it is difficult, in conjecturing the first attempts of man or his hypothetical ancestor at the expression either of percepts or concepts, to connect vocal sounds with any large number of objects, but it is readily conceivable that the characteristics of their forms and movements should have been suggested to the eye—highly exercised before the tongue—after the arms and fingers had become free for the requisite simulation or portrayal. It may readily be supposed that a troglodyte man would desire to communicate the finding of a cave in the vicinity of a pure pool, circled with soft grass, and shaded by trees bearing edible fruit. No sound of nature is connected with any of those objects, but the position and size of the cave, its distance and direction, the water, its quality, and amount, the verdant circling carpet, and the kind and height of the trees could have been made known by pantomime in the days of the mammoth, if articulate speech had not then been established, as Indians or deaf-mutes now communicate similar information by the same agency.

CONCLUSIONS.

It may be conceded that after man had attained to all his present faculties, he did not choose between the adoption of voice and gesture, and never, with those faculties, was in a state where the one was used to the absolute exclusion of the other. The epoch, however, to which our speculations relate, is that in which he had not reached the present symmetric development of his intellect and of his bodily organs, and the inquiry is, which mode of communication was earliest in adaptation to his simple wants and unformed intelligence. With the voice he could imitate distinctively but the few sounds of nature, while with gesture he could exhibit actions, motions, positions, forms, dimensions, directions and distances, with their derivatives and analogues. It would seem from this unequal division of capacity that oral speech remained rudimentary long after gesture had become an efficient instrument of thought and expression. With due allowance for all purely imitative sounds and for the spontaneous

action of the vocal organs under excitement, it appears that the connection between ideas and words is only to be explained by a compact between the speaker and hearer which supposes the existence of a prior mode of communication. This was probably by gesture, which, in the happy phrase of Sayce, "like the rope-bridges of the Himalayas or the Andes, formed the first rude means of communication between man and man." At least we may gladly accept it as a clew leading us out of the labyrinth of philologic confusion, and as regulating the immemorial search for man's pristine speech.

PAPERS READ.

COMPARATIVE DIFFERENCES IN THE IROQUOIS GROUP OF DIALECTS.

By ERMINNIE A. SMITH, of Jersey City, N. J.

[ABSTRACT.]

ASSUMING these dialects to be of common stock, it is not difficult to discover some of the causes which have led to at least a few of the changes, the final result of which has been that the conversation of the Tuscarora is almost unintelligible to the Mohawk, and that in turn partially so to the Oneida, Onondaga, Cayuga, and Seneca.

Which has the best claim to priority, as being the fundamental, cannot yet be decided, for while popular tradition and some philologic deductions might give to the Mohawk that claim, the extreme isolation of the Tuscaroras may have caused them to adhere more rigidly to the mother-tongue.

To me the Tuscarora dialect seems to be the most replete in itself, as can be seen in its table of numerals, where no such *mélange* appears as in the other dialects.

M. Cuoq, in his valuable "Etudes Philologiques sur quelques langues Sauvages de l'Amérique," entitles his second section "Principles of the Iroquois Grammar," and then proceeds to lay down the principles of the Mohawk grammar.

For this he gives no reason, which, however, probably was that he was more conversant with the Mohawk, having labored so long among that tribe, and rightly judging that the same grammatical and syntactic construction could be applied to the whole group.

The brochure of M. Cuoq is in his native language, the French, and his vast linguistic knowledge has enabled him to fathom the Indian languages with all their marvellous and astonishing phenomena, and to penetrate their sense in all its shades. At the same time as the grammatical construction is made to conform as far as possible to the French as its model, and to appeal more particularly to those of that nationality who would use it as a standard of comparison or as an aid to its understanding, it seems that

while accepting it as representing the Mohawk, it is quite unnecessary that the grammatical construction of the other five dialects should be as fully elaborated in order to institute a comparison, even if it were possible for me to accomplish it. Those who are familiar with the wonderful research displayed in the brochure of M. Cuoq, and who cannot fail to admit its great value as a contribution to Indianology, must however deplore the almost merciless censoriousness which the author has displayed toward his forerunners, the pioneers in the science, so that it is not remarkable that in the last two decades no one has ventured into this Iroquois warpath, waiting forsooth until this Titan had laid down his pen, mightier indeed than the tomahawk of those whose language he had conquered. It is therefore not without serious misgivings that an unpretentious woman takes up the glaive, depending upon her zeal in the cause but willing to sacrifice her own vulnerable opinions if the national gallantry of so competent a critic will permit them to become a *point d'attaque* and thereby secure other contributions from this retired savant.

The great conformity in the dialects of the six tribes would alone give us authority to assume that in some pre-traditionary epoch they existed as one tribe, and many evidences go to show that so great were their power and skill that they, in that age, supplanted the fierce Algonquins.

It may then be supposed that, either the better to procure their food, or for the protection of their usurped territory, they separated themselves into at least three divisions, the Seneca, Mohawk and Tuscarora, the Mohawk later sending off the Onondagas and Oneidas as offshoots, and the Senecas doing the same by the Cayugas. Five of them at least were known to the first French settlers who, recognizing their affinity, termed them, as a whole, the Iroquois. How or why the Tuscaroras were located so far to the south we can only conjecture. It may have been that they might there serve as an outpost to protect the other tribes in their incursions among the Creeks and other belligerent savages. It was probably during this period, embracing centuries perhaps, that the changes began which have resulted in the six distinct dialects of the Iroquois and probably others not included in that name.

These variations mainly consist: 1. In modifications of the vowel which changes very materially the sound of words which,

when written, are easily perceived to have been at one time identical, as un-qua (man) in Tuscarora becomes on-gwe in Seneca.

2. By dropping the initial syllable, by suffixes, or by the incorporation of a syllable.

3. By local changes which render old terms for certain ideas or events impracticable, as, for instance, the names given to the different months or moons differ to suit the seasons, of the strawberry, the gobbling of the turkey, or corn ripening, and leaf falling, of the warmer climate to which the Tuscaroras were transplanted. Many of the words in this class have become "denotive," that is, in the changed condition of the tribe an old name may be retained when its primitive significance is gone and forgotten.

4. Changes in consonant sounds. The distinct *k* sound of the Tuscarora has the *g* sound in most of the other dialects, as û^n-kwa (man) in Tuscarora becomes on-gwe, and kû^{n}f (in) becomes gon. The Tuscarora has no *d* sound nor heavy *g*, which sounds prevail in the Seneca, the *n* and *k* sounds predominating in Tuscarora. Generally the *t* sound of the Tuscarora becomes *n* in Seneca, as thwa-tas-kwa in Tuscarora becomes swa-nas-gwa in Seneca. The sound *th* in the Tuscarora is softened to *s* in the other dialects, as tha-wa (thine) becomes sa-wû^n in Seneca. The letter *b*, which M. Cuoq says does not exist in Iroquois, is found in Tuscarora, but possibly only in borrowed words.

5. By a transposition of syllables, as the word *city*, u-tah-na of Tuscarora becomes ka-na-tah in Onondaga.

6. Words have sometimes remained unchanged, but the meanings have changed, as ka-non-sio, which in the Mohawk represents a beautiful house, signifies in Tuscarora a large house.

7. We find that compound words are frequently composed of words from two of the dialects, as is the case with many of the numerals and in many other words, for example: Kă‴-nû^{n}ñ-yă″-rhi′-h-nû^n, "lime." Kă-rhi′-h-ñû^n, burnt. O-nû^{n}ñ-yă being the Onondaga for "a stone," while the adjective "burnt" is Tuscarora. At the same time the word O-nû^{n}ñ‴-yăh, "a stone" of the Onondaga, represents "brick" in the Tuscarora.

8. By intonations and inflections, like the Germans of Dresden, the Senecas almost sing their speech.

9. By far the greatest change was produced by the new words added to each of the dialects to represent the influx of new ideas attending the advent of the white man among them; these words

differing according to the circumstances attending the first sight of an object and the temperament of the beholders. In many instances the English or the French words were adopted, but with such changes as to render them scarcely recognizable.

The last class has often proved the "bone of contention" among philologists; as in the case of the much contested word "Hă″-we-ni′-yu-h" in the table of comparison, the word which with very slight variations stands for God in all the six dialects.

M. Cuoq tells us that in the Mohawk there are interjections common to men and others to women; of these he gives no examples and I have been unable to find any with such distinction in the other dialects. He also tells us there is no distinction of gender in that language, but that "beings are divided into two classes, etc.;" but the gender of all the Iroquois nouns which I have studied appears to be as clearly defined as in the English.

While M. Cuoq finds according to the French interpretation of the article that it is wanting in these dialects (and many others are of the same opinion), it appears to me that the independent particle *hah* of the Tuscarora, *tca* of the Onondaga, and *ne* of the Seneca represent that part of speech in the English acceptation of the definite article, while the prevailing initial syllable *u* of the Tuscarora, invariably *o* in the other five dialects, seems in a manner to take the place of our indefinite article, as it is always dropped when the sense is in any way restricted.

In *liber* (book) of the Latin, we find the terms bark, parchment, leaf, paper, and the derivatives library, etc. In U-hia-tûⁿ-sta of the Tuscarora, we find also bark, parchment, paper and book.

To institute a true comparison among different languages, we must go back of all language to the governing thought which language is designed to convey. In obtaining the names of plants, I find that the Indians call some "the greater," and some "the little," or "the lesser" of whatever *species* they may be speaking; as in English *we* have the "greater" centaury and the "smaller" centaury. The Indians use the word u′-h-kă″-shä″h, "petticoat," in the sense of effeminate, as is customary in English.

The workings of the human mind, are they not universally the same as shown by the analysis of these unwritten dialects of a people unlearned in philosophy or philology, whose natural

anguage, suited to the thought of its producers, is only prolix, lumsy and forced when applied to the ideas of those who have eached that higher stage of culture where language has been ermed "the means of concealing thought?"

I trust that in presenting a few of the differences in this, one f the highest groups of Indian languages, I have made known ome of the possibilities of what can be accomplished by an aim follow the advice of Mr. Trumbull regarding the "resolution of ynthesis by analysis," by examining those words which the Indian as so skilfully put together, and in this manner arriving at dia-ectical differences.

In endeavoring to fulfil the aim of this paper and availing my-elf of the Mohawk of M. Cuoq, I have only alluded to the oints, in which, in his book written for the French people, a ifference was perceptible when the same parts of speech were pplied in their English sense.

From the total absence of all allusion in his rules to the numer-us exceptions in the other dialects, it is more than probable that I. Cuoq was unacquainted with any other than the Mohawk, but n the incorporated particles tasera-tsera of that dialect which he erms "a kind of cement," I was able to discover the "tchra" nd "sta" over which I had been greatly puzzled in Tuscarora.

I would also acknowledge my indebtedness to him for other aluable hints upon which to proceed in future investigations.

Their language is almost the only existing monument relating o the aboriginal state of the Iroquois. While it is yet in our power hall we not hasten to decipher its inscription with its revelations f the dusky past?

PHONETICS OF THE KA'YOWE LANGUAGE. By ALBERT S. GATSCHET, of Washington, D. C.

[ABSTRACT.]

THE Ka'yowē or Kiowa Indians, in Spanish Caigua, are an rratic equestrian people, whose ancient home is in the eastern art of Colorado on the headwaters of the north and south fork f the Platte river. During the historical period they always ppear as the associates of the Comanches, although they speak a

language which possesses no affinity with that of the Comanches. They call themselves Ko'-i, in the plural Ko'-igu.

The phonetics of Ka'yowē are perhaps as intricate as those of most other unwritten languages, and the number of sounds in this language are rather considerable, for if we count the long vowels separately from the short ones, we find thirty-eight sounds, and with the *nasalized* vowels forty-four, just as many sounds as there are sounds in the English language.

The most conspicuous fact in the phonetic series of this language is the prevalence of the nasals, and the total absence of the palatals *tch* and *dsh* (Eng. j), which are so frequent in the majority of the American tongues, and of *z* and *v*. The guttural and dental series are well represented, while in the labial series *p*, *b* and *m* are the only frequent sounds.

Nasalizing is a prominent feature in Ka'yowē phonetics, more so in the vocalic than in the consonantic series. The dl is a peculiar sound of the language, occurring also in other Mississippian languages, as in the Pawnee and its cognate dialects. The first syllables of words end just as often in a consonant as in a vowel, but all other syllables usually terminate in a clear or nasalized vowel. Accentuation often makes a vowel long: pa'-upado or pa-upā'do "*threefold.*"

An unbounded freedom pervades the phonetics of the Indian languages; this can best be observed in the constant permutation or interchangeability of the sounds produced by the same vocal organ, and this also explains why the languages are written down so differently even by competent investigators. Examples taken from Ka'yowē will illustrate this in a singular manner. Thus du'ndei, *mouse*, can be pronounced also tû'nte-i, tu'nte-i; o'nsû, *to start out*, ho'nsû, a'nsû, a^{m} sû; o'logi, *money*, o'lonki, o'lo^{n}gi, olo'mki; ndî'nda, *ours*, di'da, ndi'da; o-ata'm, *wild cat*, o-ûtā'm; o'dl, *hair*, ō'l, u-o'l; sî'b'nda, *it rains*, se'b'nda, sīb'da; ta'ki, *good*, ta'-aki, to'-iki, toi'gi.

Of other phonetic peculiarities in Ka'yowē, I mention the shifting of the accent from syllable to syllable in some polysyllabic terms, for rhetoric reasons. Apheresis is frequent and apocope still more so. The language has a decided tendency toward monosyllabism; probably this tendency is as strong as in English, and by all means stronger than we observe it in French.

Animal Myths. By Erminnie A. Smith, of Jersey City, N. J.

[ABSTRACT.]

To those familiar with the myths of all countries, it is unnecessary to look back for testimony to the mummy-pits and hieroglyphics of Egypt, or to refer to the ancient mounds of our own country, where often the well defined outline of some animal points to the fact that there existed an undefined, closer communion between the whole human race in its infancy and the animal world than in this age of civilization, when man looks down with contempt on those living beings which, in the glory of his worldly wisdom, he terms the "lower animals" or "brute creation." In none of these myths do we find this more interestingly demonstrated than in that of the aborigines of our own country, and above all in that of their highest type, the Iroquois.

To them Nature was a book from whose picture-writing they read such of her secrets as served their simple needs. From the nature of the trees and their known requirements they could read, as from a guide-post, the path to the rich bottoms where water-courses would supply food for their wigwams and the fields of maize would flourish; from the growth of mosses on the bark they had by day, in the illimitable forest, as sure a guide on their way as the compass, and by night had they not the pole star? The simple Indian, with mind unfettered by teachings, had a warm fellow-feeling with all of external nature which he could utilize,—but the mysterious, that which he could not comprehend or use, overawed him. Therefore the echo, the thunder, and the wind were considered divinities.

The study of the mythology of Greece is considered the basis of a liberal literary education; but in the ideas of the primitive inhabitants of our continent there may also be found traces of true poetic feeling. Their knowledge of animal life was almost instinctive, and many were the lessons in natural history taught around the camp fire in the long winter evenings, either by the narration of hunting exploits, or through a fable which, if lacking the moral lessons of those of Æsop, often excelled them in pith and ingenuity.

Such an one is the story of the "Origin of the Raccoon Tune,"

which in its repetition would lose much of the interest it possessed when told me by an old Seneca, who interspersed its narration with the songs belonging to it. This story, concerning the cunning of the hungry raccoon and his capture of the crabs, illustrates the wood-craft of the aborigines. The sole surviving crab, escaped from his enemy and perishing from thirst, is represented in the legend as resorting to profound wood lore for the discovery of the watercourse of which he is in search, by questioning each tree he approaches as to its name. The first replies that it is a pine from which, as its nature is to grow on the dry, high lands and hill-sides, the crab at once comprehends that no water is to be found in its vicinity. The next is an oak, the next a maple which flourishes on lower ground, wherefore the fainting crab takes heart; at last tired, weary and parched, he finally approaches a willow, and lo, the longed-for water is at hand.

Stories of transformations of men into beasts, and of beasts into men, are numerous and form the basis of all the stories regarding the origin of the different clans.

The Indians, unlike nearly all other barbarians, considered the thunder a benevolent agency. By most savages, thunder and lightning are regarded simply with terror, while our northern ancestors made of Thor a furious deity, to be propitiated as the ruler of mischievous spirits. Abridged from the story as told by Mr. Hale, the thunder-myth of the Indian is this:—A young brave, when out on a hunt, was accidentally wounded so that he had to be carried by his companions; they grew weary of the task and treacherously threw him into a pit by the way. He fell to the bottom and they went to the village bringing the report to the young brave's mother that they had tended him in his last agonies. When the young warrior awoke from the swoon into which he was plunged by his fall, he found himself at the bottom of a cave with an old man bending over him. The old man told him not to be alarmed for he would bring herbs which would cure him; so, under the healing influence of the old man's herbs, the youth revived. Then the old man proposed to him that they hunt in partnership. The warrior out of gratitude gave ready consent. One day the young man went out alone and found a bear of enormous size. The bulk of the slain animal was far too great for his strength; while he hesitated he saw three men of a strange appearance, with their cloud-like garments and with wings on

heir shoulders. When questioned they told him that they were hree of the thunder-spirits, of whom there were very many; they ,lso said that he must distrust the old man with whom they had een him hunting, for he was an impostor. They bade him bring he old man with him when he next went to hunt, and see what rould happen. The young warrior then hastened back to the cave rhere the old man lived and brought him along; when they ,rrived at the place where the dead bear lay, the cloud-dressed rarriors had disappeared, but the sky began to be overcast. The old man showed great uneasiness, increasing to terror, and is the storm came on he betook himself to flight, but just before ie reached the entrance of his cave he was suddenly transformed nto an enormous porcupine and just then was killed by a thunder-›olt. Now the cloud-spirits reappeared and told the young war-·ior to put on a garment like their own which they had brought 'or him. He did so and was immediately able to rise into the ıir; soon he was at his own village and appeared before his nother, who was at first terrified, thinking she had seen a ghost. Thereafter the young man lived many years in honor among his :lansmen, but every spring he donned his cloud-dress with the wings, and went rambling about the sky with the thunder-spirits ;o see all the kind things which they did for the benefit of the ıuman race, and assist in exterminating great sea-serpents which ›oisoned the waters, for this was one of the great missions of ' Hi-nuh," the thunderers.

This is a strange and significant story when contrasted with ;he Greek idea of the vengeful thunder-bolts of Jove, which as ›ften brought death to men as to the enemies of men.

The song of the robin-redbreast is, to the Tuscarora, the tender ıtory of the brave youth, who, in the glory of his war-paint, was ;ransformed into that blithesome bird.

Is it then strange that, with these ideas inherent in their ıatures, they should, when having learned of heaven and the ıpirit-world, release a little bird over the graves of their loved ›nes, that it might carry the departing spirit to its "home in the ıky," the literal interpretation of the Iroquois word for heaven?

A LAWGIVER OF THE STONE AGE. By HORATIO HALE, of Clinton, Ontario, Canada.

WHAT was the intellectual capacity of man when he made his first appearance upon the earth? Or, to speak with more scientific precision (as the question relates to material evidences), what were the mental powers of the people who fashioned the earliest stone implements, which are admitted to be the oldest remaining traces of our kind? As these people were low in the arts of life, were they also low in natural capacity? This is certainly one of the most important questions which the science of anthropology has yet to answer. Of late years the prevalent disposition has apparently been to answer it in the affirmative. Primitive man, we are to believe, had a feeble and narrow intellect, which in the progress of civilization has been gradually strengthened and enlarged. This conclusion is supposed to be in accordance with the development theory; and the distinguished author of that theory has seemed to favor this view. Yet, in fact, the development theory has nothing to do with the question. If we suppose that the existing and — so far as we know — the only species of man appeared upon the earth with the physical conformation and mental capacity which he retains at this day, we make merely the same supposition with regard to him that we make with regard to every other existing species of animal. How it was that this species came to exist is another question altogether.

Philologists regard it as an established fact that the first people who spoke an Aryan language were a tribe of barbarous nomads, who wandered in the highlands of central Asia. Those who have studied the earliest products of Aryan genius in the Vedas, the Zend-Avesta, and the Homeric songs, will be willing to admit that these wandering barbarians may have had minds capable of the highest efforts to which the human intellect is known to have attained. Yet if an irruption of Semitic or Turanian conquerors had swept that infant tribe from the earth, no trace of its existence beyond a few flint implements, and perhaps some fragments of pottery, would have remained to show that such a people had ever existed. Have we any reason to doubt that in the course of all the ages, in various parts of our globe, many tribes of men may have arisen and perished who were in natural capacity as far

superior to the primitive Aryans as these were to the races who surrounded them? Under the law of the survival of the fittest, it is not the strongest that survive, but the strongest of those that are placed in the most favorable circumstances. On any calculation of probabilities, it will seem likely enough that among the numberless small societies of men that have appeared and vanished in primeval Asia and Europe, in Africa, Australia, America, and Polynesia, there may have been some at least equal, if not superior, in mental endowments, to that fortunate tribe of central Asia, whose posterity has come to be the dominant race of our time. Among their leaders may have been men qualified to rank with the most renowned heroes, exemplars, and teachers of the human race—with Moses and Buddha, with Confucius and Solon, with Numa, Charlemagne, and Alfred, or (to come down to recent times) with the greatest and wisest among the founders of the American Republic. If the possibility of the existence of such men under such conditions cannot be denied, the facts which have lately been brought to light in regard to one such personage and the community in which he lived may have a peculiar interest and significance in their bearing on the general question of the mental capacity of uncivilized races.

It is well known that the Iroquois tribes, whom our ancestors termed the Five Nations, were, when first visited by Europeans, in the precise condition which, according to all the evidence we possess, was held by the inhabitants of the Old World during what has been designated the Stone Age. Any one who examines the abandoned site of an ancient Iroquois town will find there relics of precisely the same cast as those which are disinterred from the burial mounds and caves of prehistoric Europe,—implements of flint and bone, ornaments of shells, and fragments of rude pottery. Trusting to these evidences alone, he might suppose that the people who wrought them were of the humblest grade of intellect. But the testimony of historians, of travellers, of missionaries, and perhaps his own personal observation, would make him aware that this opinion would be erroneous, and that these Indians were, in their own way, acute reasoners, eloquent speakers, and most skilful and far-seeing politicians. He would know that for more than a century, though never mustering more than five thousand fighting men, they were able to hold the balance of power on this continent between France and England;

and that in a long series of negotiations they proved themselves qualified to cope in council with the best diplomatists whom either of those powers could depute to deal with them. It is only recently that we have learned, through the researches of a careful and philosophic investigator, the Hon. L. H. Morgan, that their internal polity was marked by equal wisdom, and had been developed and consolidated into a system of government, embodying many of what are deemed the best principles and methods of political science,—representation, federation, self-government through local and general legislatures,—all resulting in personal liberty, combined with strict subordination to public law. But it has not been distinctly known that for many of these advantages the Five Nations were indebted to one individual, who bore to them the same relation which the great reformers and lawgivers of antiquity bore to the communities whose gratitude has made their names illustrious.

A singular fortune has attended the name and memory of Hiawatha. Though actually an historical personage, and not of very ancient date, of whose life and deeds many memorials remain, he has been confused with two Indian divinities, the one Iroquois, the other Algonquin, and his history has been distorted and obscured almost beyond recognition. Through the cloud of mythology which has enveloped his memory, the genius of Longfellow has discerned something of his real character, and has made his name, at least, a household word wherever the English language is spoken. It remains to give a correct account of the man himself and of the work which he accomplished, as it has been received from the official annalists of his people. The narrative is confirmed by the evidence of contemporary wampum records, and by written memorials in the native tongue, one of which is at least a hundred years old.

According to the best evidence that can be obtained, the formation of the Iroquois confederacy dates from about the middle of the fifteenth century. There is reason to believe that prior to that time the five tribes, who are dignified with the title of nations, had held the region south of Lake Ontario, extending from the Hudson to the Genesee river, for many generations, and probably for many centuries. Tradition makes their earlier seat to have been north of the St. Lawrence river, which is probable enough. It also represents the Mohawks as the original tribe, of which the

others are offshoots; and this tradition is confirmed by the evidence of language. That the Iroquois tribes were originally one people, and that their separation into five communities, speaking distinct dialects, dates many centuries back, are both conclusions as certain as any facts in physical science. Three hundred and fifty years ago they were isolated tribes, at war occasionally with one another, and almost constantly with the fierce Algonquins who surrounded them. Not unfrequently, also, they had to withstand and to avenge the incursions of warriors belonging to more distant tribes of various stocks, Hurons, Cherokees and Dakotas. Yet they were not peculiarly a warlike people. They were a race of housebuilders, farmers, and fishermen. They had large and strongly palisaded towns, well-cultivated fields, and substantial houses, sometimes a hundred feet long, in which many kindred families dwelt together.

At this time two great dangers, the one from without, the other from within, pressed upon these tribes. The Mohegans, or Mohicans, a powerful Algonquin people, whose settlements stretched along the Hudson river, south of the Mohawks, and extended thence eastward into New England, waged a desperate war against them. In this war the most easterly of the Iroquois, the Mohawks and Oneidas, bore the brunt and were the greatest sufferers. On the other hand, the two westerly nations, the Senecas and Cayugas, had a peril of their own to encounter. The central nation, the Onondagas, were then under the control of a dreaded chief, whose name is variously given, Atotarho, Watatotahlo, Tododaho, according to the dialect of the speaker and the orthography of the writer. He was a man of great force of character and of formidable qualities, — haughty, ambitious, crafty and bold, — a determined and successful warrior, and at home, so far as the constitution of an Indian tribe would allow, a stern and remorseless tyrant. He tolerated no equal. The chiefs who ventured to oppose him were taken off one after another by secret means, or were compelled to flee for safety to other tribes. His subtlety and artifices had acquired for him the reputation of a wizard. He knew, they say, what was going on at a distance as well as if he were present; and he could destroy his enemies by some magical art, while he himself was far away. In spite of the fear which he inspired, his domination would probably not have been endured by an Indian community, but for his success in war.

He had made himself and his people a terror to the Cayugas and the Senecas. According to one account, he had subdued both of those tribes; but the record-keepers of the present day do not confirm this statement, which indeed is not consistent with the subsequent history of the confederation.

The name Atotarho signifies "entangled." The usual process by which mythology, after a few generations, makes fables out of names, has not been wanting here. In the legends which the Indian story-tellers recount in winter about their cabin fires, Atotarho figures as a being of preterhuman nature, whose head, in lieu of hair, is adorned with living snakes. A rude pictorial representation shows him seated and giving audience, in horrible state, with the upper part of his person enveloped by these writhing and entangled reptiles. But the grave Councillors of the Canadian Reservation, who recite his history as they have heard it from their fathers at every installation of a high chief, do not repeat these inventions of marvel-loving gossips, and only smile with good-humored derision when they are referred to.

There was at this time among the Onondagas a chief of high rank whose name, variously written — Hiawatha, Hayonwatha, Ayongwhata, Taoungwatha — is rendered, "he who seeks the wampum belt." He had made himself greatly esteemed by his wisdom and his benevolence. He was now past middle age. Though many of his friends and relatives had perished by the machinations of Atotarho, he himself had been spared. The qualities which gained him general respect had, perhaps, not been without influence even on that redoubtable chief. Hiawatha had long beheld with grief the evils which afflicted not only his own nation, but all the other tribes about them, through the continual wars in which they were engaged, and the misgovernment and miseries at home which these wars produced. With much meditation he had elaborated in his mind the scheme of a vast confederation which would ensure universal peace. In the mere plan of a confederation there was nothing new. There are probably few, if any, Indian tribes which have not, at one time or another, been members of a league or confederacy. It may almost be said to be their normal condition. But the plan which Hiawatha had evolved differed from all others in two particulars. The system which he devised was to be not a loose and transitory league, but a permanent government. While each nation was to retain its own coun-

:il and its management of local affairs, the general control was to be lodged in a federal senate, composed of representatives elected by each nation, holding office during good behavior, and acknowledged as ruling chiefs throughout the whole confederacy. Still further, and more remarkably, the confederation was not to be a limited one. It was to be indefinitely expansible. The avowed design of its proposer was to abolish war altogether. He wished the federation to extend until all the tribes of men should be included in it, and peace should everywhere reign. Such is the positive testimony of the Iroquois themselves; and their statement, as will be seen, is supported by historical evidence.

Hiawatha's first endeavor was to enlist his own nation in the cause. He summoned a meeting of the chiefs and people of the Onondaga towns. The summons, proceeding from a chief of his rank and reputation, attracted a large concourse. "They came together," said the narrator, "along the creeks, from all parts, to the general council-fire." But what effect the grand projects of the chief, enforced by the eloquence for which he was noted, might have had upon his auditors, could not be known. For there appeared among them a well-known figure, grim, silent and forbidding, whose terrible aspect overawed the assemblage. The unspoken displeasure of Atotarho was sufficient to stifle all debate, and the meeting dispersed. This result, which seems a singular conclusion of an Indian council—the most independent and free-spoken of all gatherings—is sufficiently explained by the fact that Atotarho had organized among the more reckless warriors of his tribe a band of unscrupulous partisans, who did his bidding without question, and took off by secret murder all persons against whom he bore a grudge. The knowledge that his followers were scattered through the assembly, prepared to mark for destruction those who should offend him, might make the boldest orator chary of speech. Hiawatha alone was undaunted. He summoned a second meeting, which was attended by a smaller number, and broke up as before, in confusion, on Atotarho's appearance. The unwearied reformer sent forth his runners a third time; but the people were disheartened. When the day of the council arrived, no one attended. Then, continued the narrator, Hiawatha seated himself on the ground in sorrow. He enveloped his head in his mantle of skins, and remained for a long time bowed down in grief and thought. At length he arose and left the town, taking his

course toward the southeast. He had formed a bold design. As the councils of his own nation were closed to him, he would have recourse to those of other tribes. At a short distance from the town (so minutely are the circumstances recounted) he passed his great antagonist, seated near a well-known spring, stern and silent as usual. No word passed between the determined representatives of war and peace; but it was doubtless not without a sensation of triumphant pleasure that the ferocious war-chief saw his only rival and opponent in council going into what seemed to be voluntary exile. Hiawatha plunged into the forest; he climbed mountains; he crossed a lake; he floated down the Mohawk river in a canoe. Many incidents of his journey are told, and in this part of the narrative alone some occurrences of a marvellous cast are related even by the official historians. Indeed, the flight of Hiawatha from Onondaga to the country of the Mohawks is to the Five Nations what the flight of Mohammed from Mecca to Medina is to the votaries of Islam. It is the turning point of their history. In embellishing the narrative at this point, their imagination has been allowed a free course. Leaving aside these marvels, however, we need only refer here to a single incident which may well enough have been of actual occurrence. A lake which Hiawatha crossed had shores abounding in small white shells. These he gathered and strung upon strings, which he disposed upon his breast, as a token to all whom he should meet that he came as a messenger of peace. And this, according to one authority, was the origin of wampum, of which Hiawatha was the inventor. That honor, however, is one which must be denied to him. The evidence of sepulchral relics shows that wampum was known to the mysterious moundbuilders, as well as in all succeeding ages. Moreover, if the significance of white wampum-strings as a token of peace had not been well known in his day, Hiawatha would not have relied upon them as a means of proclaiming his pacific purpose.

Early one morning he arrived at a Mohawk town, the residence of the noted chief Dekanawidah, whose name, in point of celebrity, ranks in Iroquois tradition with those of Hiawatha and Atotarho. It is probable that he was known by reputation to Hiawatha, and not unlikely that they were related. According to one account Dekanawidah was an Onondaga, adopted among the Mohawks. Another narrative makes him a Mohawk by birth. The proba-

bility seems to be that he was the son of an Onondaga father, who had been adopted by the Mohawks, and of a Mohawk mother. That he was not of pure Mohawk blood is shown by the fact, which is remembered, that his father had had successively three wives, one belonging to each of the three clans, Bear, Wolf, and Turtle, which compose the Mohawk nation. If the father had been a Mohawk, he would have belonged to one of the Mohawk clans, and could not then (according to the Indian law) have married into it. He had seven sons, including Dekanawidah, who, with their families, dwelt together in one of the "long houses" common in that day among the Iroquois. These ties of kindred, together with this fraternal strength, and his reputation as a sagacious councillor, gave Dekanawidah great influence among his people. But, in the Indian sense, he was not the leading chief. This position belonged to Tekarihoken (better known in books as Tecarihoga) whose primacy as the first chief of the eldest among the Iroquois nations was then, and is still, universally admitted. Each nation has always had a head-chief, to whom belonged the hereditary right and duty of lighting the council-fire, and taking the first place in public meetings. But among the Indians, as in other communities, hereditary rank and personal influence do not always, or indeed ordinarily, go together. If Hiawatha could gain over Dekanawidah to his views, he would have done much toward the accomplishment of his purposes.

In the early dawn he seated himself on a fallen trunk, near the spring from which the inhabitants of the long-house drew their water. Presently one of the brothers came out with a vessel of elm-bark, and approached the spring. Hiawatha sat silent and motionless. Something in his aspect awed the warrior, who feared to address him. He returned to the house, and said to Dekanawidah, "a man, or a figure like a man, is seated by the spring, having his breast covered with strings of white shells." "It is a guest," replied the chief; "go and bring him in. We will make him welcome." Thus Hiawatha and Dekanawidah first met. They found in each other kindred spirits. The sagacity of the Mohawk chief grasped at once the advantages of the proposed plan, and the two worked together in perfecting it, and in commending it to the people. After much discussion in council, the adhesion of the Mohawk nation was secured. Dekanawidah then despatched two of his brothers as ambassadors to the nearest tribe, the Oneidas, to

lay the project before them. The Oneida nation is deemed to be a comparatively recent offshoot from the Mohawks. The difference of language is slight, showing that their separation was much later than that of the Onondagas. In the figurative speech of the Iroquois, the Oneida is the son, and the Onondaga is the brother, of the Mohawk. Dekanawidah had good reason to expect that it would not prove difficult to win the consent of the Oneidas to the proposed scheme. But delay and deliberation mark all public acts of the Indians. The ambassadors found the leading chief, Odatshehte, at his town on the Oneida creek. He received their message in a friendly way, but required time for his people to consider it in council. "Come back in another day," he said to the messengers. In the political speech of the Indians, a day is understood to mean a year. The envoys carried back the reply to Dekanawidah and Hiawatha, who knew that they could do nothing but wait the prescribed time. After the lapse of a year, they repaired to the place of meeting. The treaty which initiated the great league was then and there ratified between the representatives of the Mohawk and Oneida nations. The name of Odatshehte means "the quiver-bearer;" and as Atótarho, "the entangled," is fabled to have had his head wreathed with snaky locks, and as Hiawatha, "the wampum-seeker," is represented to have wrought shells into wampum, so the Oneida chief is reputed to have appeared at this treaty bearing at his shoulder a quiver full of arrows.

The Onondagas lay next to the Oneidas. To them, or rather to their terrible chief, the next application was made. The first meeting of Atotarho and Dekanawidah is a notable event in Iroquois history. At a later day, a native artist sought to represent it in an historical picture, which has been already referred to. Atotarho is seated in solitary and surly dignity, smoking a long pipe, his head and body encircled with contorted and angry serpents. Standing before him are two figures which cannot be mistaken. The foremost, a plumed and cinctured warrior, depicted as addressing the Onondaga chief, holds in his right hand, as a staff, his flint-headed spear,— the ensign which marks him as the representative of the Kanienga, or "People of the Flint,"— for so the Mohawks style themselves. Behind him another plumed figure bears in his hand a bow with arrows, and at his shoulder a quiver. Divested of its mythological embellishments,

the picture rudely represents the interview which actually took place. The immediate result was unpromising. The Onondaga chief coldly refused to entertain the project, which he had already rejected when proposed by Hiawatha. The ambassadors were not discouraged. Beyond the Onondagas were scattered the villages of the Cayugas, a people described by the Jesuit missionaries, at a later day, as the most mild and tractable of the Iroquois. They were considered an offshoot of the Onondagas, to whom they bore the same filial relation which the Oneidas bore to the Mohawks. The journey of the advocates of peace through the forest to the Cayuga capital, and their reception, are minutely detailed in the traditionary narrative. The Cayugas, who had suffered from the prowess and cruelty of the Onondaga chief, needed little persuasion. They readily consented to come into the league, and their chief, Akahenyonk, "the wary spy," joined the Mohawk and Oneida representatives in a new embassy to the Onondagas. Acting probably upon the advice of Hiawatha, who knew better than any other the character of the community and the chief with whom they had to deal, they made proposals highly flattering to the self-esteem which was the most notable trait of both ruler and people. The Onondagas should be the leading nation of the confederacy. Their chief town should be the federal capital, where the great councils of the league should be held, and where its records should be preserved. The nation should be represented in the council by fourteen senators, while no other nation should have more than ten. And as the Onondagas should be the leading tribe, so Atotarho should be the leading chief. He alone should have the right of summoning the federal council, and no act of the council to which he objected should be valid. In other words, an absolute veto was given to him. To enhance his personal dignity two high chiefs were appointed as his special aids and counsellors, his "secretaries of state," so to speak. Other insignia of preëminence were to be possessed by him; and, in view of all these distinctions, it is not surprising that his successor, who, two centuries later, retained the same prerogatives, should have been occasionally styled by the English colonists "the emperor of the Five Nations." It might seem, indeed, at first thought, that the founders of the confederacy had voluntarily placed themselves and their tribes in a position of almost abject subserviency to Atotarho and his followers. But they knew too

well the qualities of their people to fear for them any political subjection. It was certain that when once the league was established, and its representatives had met in council, character and intelligence would assume their natural sway, and mere artificial rank and dignity would be little regarded. Atotarho and his people, however, yielded either to these specious offers or to the pressure which the combined urgency of the three allied nations now brought to bear upon them. They finally accepted the league; and the great chief, who had originally opposed it, now naturally became eager to see it as widely extended as possible. He advised its representatives to go on at once to the westward, and enlist the populous Seneca towns, pointing out how this might best be done. This advice was followed, and the adhesion of the Senecas was secured by giving to their two leading chiefs, Kanyadariyo ("beautiful lake") and Shadekaronyes ("the equal skies"), the offices of military commanders of the confederacy, with the title of door-keepers of the "Long-House,"—that being the figure by which the league was known.

The six national leaders who have been mentioned — Dekanawidah for the Mohawks, Odatshehte for the Oneidas, Atotarho for the Onondagas, Akahenyonk for the Cayugas, Kanyadariyo and Shadekaronyes for the two great divisions of the Senecas — met in convention near the Onondaga Lake, with Hiawatha for their adviser, and a vast concourse of their followers, to settle the terms and rules of their confederacy, and to nominate its first council. Of this council, nine members (or ten, if Dekanawidah be included) were assigned to the Mohawks, a like number to the Oneidas, fourteen to the lordly Onondagas, ten to the Cayugas, and eight to the Senecas. Except in the way of compliment, the number assigned to each nation was really of little consequence, inasmuch as, by the rule of the league, unanimity was exacted in all their decisions. This unanimity, however, did not require the suffrage of every member of the council. The representatives of each nation first deliberated apart upon the question proposed. In this separate council the majority decided; and the leading chief then expressed in the great council the voice of his nation. Thus the veto of Atotarho ceased at once to be peculiar to him, and became a right exercised by each of the allied nations. This requirement of unanimity, embarrassing as it might seem, did not prove to be so in practice. Whenever a question arose on which

opinions were divided, its decision was either postponed, or some compromise was reached which left all parties contented.

The first members of the council were appointed by the convention, — under what precise rule is unknown; but their successors came in by a method in which the hereditary and the elective systems were singularly combined, and in which female suffrage had an important place. When a chief died or (as sometimes happened) was deposed for incapacity or misconduct, some member of the same family succeeded him. Rank followed the female line; and this successor might be any descendant of the late chief's mother or grandmother, — his brother, his cousin or his nephew, — but never his son. Among many persons who might thus be eligible, the selection was made in the first instance by a family council. In this council the "chief matron" of the family, a noble dame whose position and right were well defined, had the deciding voice. This remarkable fact is affirmed by the Jesuit missionary Lafitau, and the usage remains in full vigor among the Canadian Iroquois to this day. If there are two or more members of the family who seem to have equal claims, the nominating matron sometimes declines to decide between them, and names them both or all, leaving the ultimate choice to the nation or the federal council. The council of the nation next considers the nomination, and if dissatisfied, refers it back to the family for a new designation. If content, the national council reports the name of the candidate to the federal senate, in which resides the power of ratifying or rejecting the choice of the nation; but the power of rejection is rarely exercised, though that of expulsion for good cause is not unfrequently exerted. The new chief inherits the name of his predecessor. In this respect, as in some others, the resemblance of the Great Council to the English House of Peers is striking. As Norfolk succeeds to Norfolk, so Tekarihoken succeeds Tekarihoken. The great names of Hiawatha and Atotarho are still borne by plain farmer-councillors on the Canadian Reservation.

When the League was established, Hiawatha had been adopted by the Mohawk nation as one of their chiefs. The honor in which he was held by them is shown by his position on the roll of councillors, as it has been handed down from the earliest times. As the Mohawk nation is the "elder brother," the names of its chiefs are first recited. At the head of the list is the lead-

ing Mohawk chief, Tekarihoken, who represents the noblest lineage of the Iroquois stock. Next to him, and second on the roll, is the name of Hiawatha. That of his great colleague, Dekanawidah, nowhere appears. He was a member of the first council; but he forbade his people to appoint a successor to him. "Let the others have successors," he said proudly, "for others can advise you like them. But I am the founder of your league, and no one else can do what I have done."

The boast was not unwarranted. Though planned by another, the structure had been reared mainly by his labors. But the Five Nations, while yielding abundant honor to the memory of Dekanawidah, have never regarded him with the same affectionate reverence which has always clung to the name of Hiawatha. His tender and lofty wisdom, his wide-reaching benevolence, and his fervent appeals to their better sentiments, enforced by the eloquence of which he was master, touched chords in the popular heart which have continued to respond until this day. Fragments of the speeches in which he addressed the council and the people of the league are still remembered and repeated. The fact that the league only carried out a part of the grand design which he had in view is constantly affirmed. Yet the failure was not due to lack of effort. In pursuance of his original purpose, when the league was firmly established, envoys were sent to other tribes to urge them to join it or at least to become allies. One of these embassies penetrated to the distant Cherokees, the hereditary enemies of the Iroquois nations. For some reason with which we are not acquainted — perhaps the natural suspicion or vindictive pride of that powerful community — this mission was a failure. Another, despatched to the western Algonquins, had better success. A strict alliance was formed with the far-spread Ojibway tribes, and was maintained inviolate for at least two hundred years, until at length the influence of the French, with the sympathy of the Ojibways for the conquered Hurons, undid to some extent, though not entirely, this portion of Hiawatha's work.

His conceptions were beyond his time, and beyond ours; but their effect, within a limited sphere, was very great. For more than three centuries the bond which he devised held together the Iroquois nations in perfect amity. It proved, moreover, as he intended, elastic. The territory of the Iroquois, constantly extending as their united strength made itself felt, became the "Great Asy-

um" of the Indian tribes. Of the conquered Eries and Hurons, many hundreds were received and adopted among their conquerors. The Tuscaroras, expelled by the English from North Carolina, took refuge with the Iroquois, and became the sixth nation of the League. From still further south, the Tuteloes and Saponies, of Dakota stock, after many wars with the Iroquois, fled to them from their other enemies, and found a cordial welcome. A chief still sits in the council as a representative of the Tuteloes, though the tribe itself has been swept away by disease, or absorbed in the larger nations. Many fragments of tribes of Algonquin lineage — Delawares, Nanticokes, Mohicans, Missis-sagas,—sought the same hospitable protection, which never failed them. Their descendants still reside on the Canadian Reservation, which may well be styled an aboriginal "refuge of nations,"—affording a striking evidence in our own day of the persistent force of a great idea, when embodied in practical shape by the energy of a master mind.

The name by which their constitution or organic law is known among them is *kayánerenh*, to which the epitaph *kōwa*, "great," is frequently added. This word, *kayánerenh*, is sometimes rendered "law," or "league," but its proper meaning seems to be "peace." It is used in this sense by the missionaries, in their translations of the scriptures and the prayer-book. In such expressions as "the Prince of Peace," "the author of peace," "give peace in our time," we find *kayánerenh* employed with this meaning. Its root is *yaner*, signifying "noble," or "excellent," which yields, among many derivatives, *kayánere*, "goodness," and *kayánerenh*, "peace," or "peacefulness." The national hymn of the confederacy, sung whenever their "Condoling Council" meets, commences with a verse referring to their league, which is literally rendered, "We come to greet and thank the PEACE" (*kayánerenh*). When the list of their ancient chiefs, the fifty original Councillors, is chanted in the closing litany of the meeting, there is heard from time to time, as the leaders of each clan are named, an outburst of praise, in the words —

> "This was the roll of you —
> You that were joined in the work,
> You that confirmed the work,
> The GREAT PEACE." (*Kayánerenh-kowa.*)

The regard of Englishmen for their Magna Charta and Bill of

Rights, and that of Americans for their national Constitution, seem weak in comparison with the intense gratitude and reverence of the Five Nations for the "Great Peace" which Hiawatha and his colleagues established for them.

Of the subsequent life of Hiawatha, and of his death, we have no sure information. The records of the Iroquois are historical, and not biographical. As Hiawatha had been made a chief among the Mohawks, he doubtless continued to reside with that nation. A tradition, which is in itself highly probable, represents him as devoting himself to the congenial work of clearing away the obstructions in the streams which intersect the country then inhabited by the confederated nations, and which formed the chief means of communication between them. That he thus, in some measure, anticipated the plans of De Witt Clinton and his associates, on a smaller scale, but with perhaps a larger statesmanship, we may be willing enough to believe. A wild legend, recorded by some writers, but not told of him by the Canadian Iroquois, and apparently belonging to their ancient mythology, gives him an apotheosis, and makes him ascend to heaven in a white canoe. It may be proper to dwell for a moment on the singular complication of mistakes which has converted this Indian reformer and statesman into a mythological personage.

When by the events of the Revolutionary war the original confederacy was broken up, the larger portion of the people followed Brant to Canada. The refugees comprised nearly the whole of the Mohawks, and the greater part of the Onondagas and Cayugas, with many members of the other nations. In Canada their first proceeding was to reëstablish, as far as possible, their ancient league, with all its laws and ceremonies. The Onondagas had brought with them most of their wampum records, and the Mohawks jealously preserved the memories of the federation, in whose formation they had borne a leading part. The history of the league continued to be the topic of their orators whenever a new chief was installed into office. Thus the remembrance of the facts has been preserved among them with much clearness and precision, and with very little admixture of mythological elements. With the fragments of the tribes which remained on the southern side of the Great Lakes the case was very different. Except among the Senecas, who, of all the Five Nations, had had least to do with the formation of the league, the ancient families

hich had furnished the members of their senate, and were the onservators of their history, had mostly fled to Canada or the Vest. The result was that among the interminable stories with hich the common people beguile their winter nights, the traditions f Atotarho and Hiawatha became intermingled with the legends of heir mythology. An accidental similarity, in the Onondaga diaect, between the name of Hiawatha and that of one of their anent divinities, led to a confusion between the two, which has nisled some investigators. This deity bears, in the sonorous Mohawk tongue, the name of Aronhiawagon, meaning "the Holder f the Heavens." The early French missionaries, prefixing a article, made the name in their orthography, Tearonhiaouagon. Ie was, they tell us, "the great god of the Iroquois." Among he Onondagas of the present day, the name is abridged to Taoniawagi, or Tahiawagi. The confusion between this name and hat of Hiawatha (which, in another form, is pronounced Tayonratha) seems to have begun more than a century ago; for Pyreus, the Moravian missionary, heard among the Iroquois (acording to Heckewelder) that the person who first proposed the eague was an ancient Mohawk, named Thannawege. Mr. J. V. I. Clark, in his interesting History of Onondaga, makes the ame to have been originally Ta-oun-ya-wat-ha, and describes the earer as "the deity who presides over fisheries and huntingrounds." He came down from heaven in a white canoe and fter sundry adventures, which remind one of the labors of Herules, assumed the name of Hiawatha (signifying, we are told, "a ery wise man"), and dwelt for a time as an ordinary mortal among men, occupied in works of benevolence. Finally, after ounding the confederacy and bestowing many prudent counsels pon the people, he returned to the skies by the same conveyance n which he had descended. This legend was communicated by Clark to Schoolcraft, when the latter was compiling his "Notes on he Iroquois." Mr. Schoolcraft, pleased with the poetical cast of he story and the euphonious name, made confusion worse conounded by transferring the hero to a distant region and identifying im with Manabozho, a fantastic divinity of the Ojibways. Schoolraft's volume, absurdly entitled "The Hiawatha Legends," has ot in it a single fact or fiction relating either to Hiawatha himelf or to the Iroquois deity Aronhiawagon. Wild Ojibway stories oncerning Manabozho and his comrades form the staple of its ontents. But it is to this collection that we owe the charming

poem of Longfellow; and thus, by an extraordinary fortune, a grave Iroquois lawgiver of the fifteenth century has become, in modern literature, an Ojibway demigod, son of the West Wind, and companion of the tricksy Paupukkeewis, the boastful Iagoo, and the strong Kwasind. If a Chinese traveller, during the middle ages, inquiring into the history and religion of the western nations, had confounded King Alfred with King Arthur, and both with Odin, he would not have made a more preposterous confusion of names and characters than that which has hitherto disguised the genuine personality of the great Onondaga reformer.

About the main events of his history, and about his character and purposes, there can be no reasonable doubt. We have the wampum belts which he handled, and whose simple hieroglyphics preserve the memory of the public acts in which he took part. We have, also, in the Iroquois "Book of Rites," a still more clear and convincing testimony to the character both of the legislator and of the people for whom his institutions were designed. This book, sometimes called the "Book of the Condoling Council," might properly enough be styled an Iroquois Veda. It comprises the speeches, songs and other ceremonies, which, from the earliest period of the confederacy, have composed the proceedings of their council when a deceased chief is lamented and his successor is installed in office. The fundamental laws of the league, a list of their ancient towns, and the names of the chiefs who constituted their first council, chanted in a kind of litany, are also comprised in the collection. The contents, after being preserved in memory like the Vedas, for many generations, were written down by desire of the chiefs, when their language was first reduced to writing and the book is therefore more than a century old. Its language, archaic when written, is now partly obsolete, and is fully understood by only a few of the oldest chiefs. It is a genuine Indian composition, and must be accepted as disclosing the true character of its authors. The result is remarkable enough. Instead of a race of rude and ferocious warriors, we find in this book a kindly and affectionate people, full of sympathy for their friends in distress, considerate to their women, tender to their children, anxious for peace, and imbued with a profound reverence for their constitution and its authors. We become conscious of the fact that the aspect in which these Indians have presented themselves to the outside world has been in a large measure deceptive and factitious. The ferocity, craft, and cruelty, which have been

eemed their leading traits, have been merely the natural accom-animents of wars of self-preservation, and no more indicated heir genuine character than the war-paint, plume, and tomahawk f the warrior displayed the customary guise in which he ap-eared among his own people. The cruelties of war, when war s a struggle for national existence, are common to all races. he persistent desire for peace, pursued for centuries in federal nions, and in alliances and treaties with other nations, has been nanifested by few as steadily as by the countrymen of Hiawatha. he sentiment of universal brotherhood, which directed their olity, has never been so fully developed in any branch of the ryan race, unless it may be found incorporated in the religious uietism of Buddha and his followers.

To come back to our first proposition,—it is unquestionable hat the Iroquois, when they framed the political system which ex-ibited this singular force of intellect and elevation of character, vere a people of the Stone Age; and there is no good reason for upposing that they were superior in character and capacity to he people of the most primitive times. What we know of them ntitles us to affirm that the makers of the earliest flint imple-nents may have been equal, if not superior, in natural powers to he members of any existing race. And as language is the out-rowth and image of the mental faculties, it is not impossible, r even unlikely, that among the languages spoken by the people f those early ages, there may have been some as far superior in onstruction and power of expression to any tongue of modern Europe, as the languages of the barbarous Greeks and Germans, thousand years before the Christian era, were superior to the peech of the highly civilized Egyptians.

The conclusions to which these facts and reasonings point are f great scientific importance. As there could be no sound as-ronomy while the notion prevailed that the earth was the centre f the universe, and no science of history while each nation ooked with contempt upon every other people, so we can hope or no complete and satisfying science of man and of human peech until our minds are disabused of those other delusions of elf-esteem which would persuade us that superior culture implies uperior capacity, and that the particular race and language which ve happen to claim as our own are the best of all races and lan-uages.

BUFFALO DRIVES ON THE ROCK RIVER IN WISCONSIN: AN EXPLANATION OF THE LONG MOUNDS. By S. D. PEET, of Clinton, Wis.

THE emblematic mounds of Wisconsin have been the subject of much speculation. Certain writers have considered them to be mere effigies, made to imitate the forms of various wild animals, merely as matters of fancy. The author of this paper has however hitherto maintained that they were used for totems or tribal signs. Their use as connected with shooting game has not until recently occurred to any one. The writer was however led to take this view of them from the study of mounds of a certain class which are common, but which are not effigies. These mounds are simply long tapering mounds but are associated with the groups of emblematic mounds. They are frequently found in pairs, running parallel with one another, to a length varying from one to three and four hundred feet.

It was ascertained, too, that these long mounds were generally situated near the bank of some stream, sometimes on the bluffs just above but near some gully or break in the bluff, sometimes on the bottom land or first terrace, but just below the opening in the upper terrace or bluff line. Frequently these long parallel mounds are associated with certain emblematic mounds which, from their situation and extensive outlook, were ascertained to be signal or observatory mounds.

These mounds frequently command an extensive view, in fact, so extensive, that the writer has been puzzled to know how the builders of them could have observed an enemy at any such distances.

In visiting a group of long mounds near Indian Ford on the Rock river, the idea was suggested that both the lookout mounds and the long tapering mounds were used for the same purpose, namely, the hunting or driving of buffalo. Indian Ford is a place well known as the traditional fording place of the aborigines. It is situated near the junction of the Catfish and the Rock rivers, a place which is peculiarly favorable for wild game.

The mounds at this point are situated on the inner side of these forks between the rivers, and are so closely connected with a break in the bluff and with the ford, as at once to give rise to the idea that they were the driveways for game of a larger sort.

They are situated in pairs—but in pairs which run from the luff to the very brink of the river. Other mounds also flank the arallel lines but converge to a point near the bank. Others too un parallel with the bank of the river leaving only a narrow way etween them and the river. Taken together, the group most learly conveyed the idea that they were designed for shooting uffalo. This idea was conveyed not only by the situation of the nounds, but by the distance (from 80 to 100 feet) intervening be- ween the parallel mounds, and especially by the form of the mounds hemselves.

It is known that the aborigines had no horses, and the question vould be how, with the herds of buffalo rushing as they often do, hey could contrive to shoot them and not be trampled down them- elves. The explanation offered is that by standing on these long ows of mounds, the hunters would not only be above the herd but vould be able to shoot into it without danger from attack. The ex- lanation of the signal or observatory mounds is, that they were for he purpose of watching the herds in their distant approach and he number of hunters could be rallied at the time so that the game hould be driven through the trap or driveway.

The observatory mounds are frequently associated with the ta- ering mounds and are near by, especially if the parallel lines are n the bluff above. But at times if the parallel lines or drive- ays are below the bluff, these observatories are on the summit at distance but near the breaks in the bluff. They are generally rtles which may have been the tribal sign. Buffalo effigies are t times found near the driveways.

Vorked Shells in New England Shellheaps. By Edward S. Morse, of Salem, Mass.

[ABSTRACT.]

In this paper attention was called to the fact that heretofore no orked shells had been found in the New England shellheaps. similar absence had been noticed in the Japanese shellheaps. Vorked shells were not uncommon in the shellheaps of Florida nd the Gulf States. Mr. Morse then exhibited specimens of the

common beach cockle (*Lunatia heros*) which seemed to show unmistakable signs of having been worked. The work consisted in cutting out a portion of the outer whorl near the suture. In a number of naturally broken shells of this species, both ancient and recent, while a few showed a tendency to break in this way, the greater proportion of them broke away below the suture.

Ancient Japanese Bronze Bells. By Edward S. Morse, of Salem, Mass.

[ABSTRACT.]

The author described the so-called Japanese Bronze Bells which are dug up in Japan. These bells had been described and figured by Prof. Monroe in the Proceedings of the New York Academy of Sciences. Mr. Kanda, an eminent Japanese archæologist, had questioned their being bells from their peculiar structure.

Mr. Morse had seen a number of bells of different kinds, some of considerable antiquity, but none of them approached these so-called bronze bells. Mr. Kanda had suggested that they were the ornaments which were formerly hung from the corners of pagoda roofs, but the fact that none of them showed signs of wear at the point of support, rendered this supposition untenable. Mr. John Robinson, of Salem, the author of a work on Ferns, had given the first suggestion as to the possible use of these objects. He has asked why they may not have been covers to incense burners. Curiously enough, old incense burners are dug up which have the same oval shape that a section of the bell shows. The bell has openings at the base and also at the sides and top, so that the smoke of burning incense might escape. It is quite evident that these objects are neither bells nor pagoda ornaments, and this suggestion of Mr. Robinson may possibly lead to some clew regarding their origin.

CHANGES IN MYA AND LUNATIA SINCE THE DEPOSITION OF THE NEW ENGLAND SHELLHEAPS. By EDWARD S. MORSE, of Salem, Mass.

[ABSTRACT.]

THIS communication embraced a comparison between the shells peculiar to the ancient deposits made by the Indians along the coast of New England, and similar species living on the coast at the present time. Mr. Morse referred to similar comparisons which he made in Japan, wherein he had found marked changes to have taken place; changes which showed that the proportions of the shells had greatly altered.

He had made a large number of measurements of shells from a few shellheaps of Maine and Massachusetts, and had obtained very interesting results. The common clam (Mya) from the shell-heaps of Goose Island, Maine, Ipswich, Mass., and Marblehead, Mass., in comparison with recent forms of the same species collected in the immediate vicinity of these ancient deposits, showed that the ancient specimens were higher in comparison with their length than the recent specimens.

A comparison of the common beach cockle (Lunatia) from the shellheaps of Marblehead, Mass., showed that the ancient form had a much more elevated spire than the recent form living on the shore to-day, and this variation curiously enough was in accordance with what he had observed in a species of Natica in the Japanese shellheaps.

THE UNCIVILIZED MIND IN THE PRESENCE OF HIGHER PHASES OF CIVILIZATION. By OTIS T. MASON, of Washington, D. C.

THE study of comparative sociology starts out with two assumptions: first, that the human race set out on its journey of life in a condition of absolute poverty — devoid of experience, social and political organization, language, or religion; in short, wanting all things excepting its unlimited capabilities and the resources of nature. The second assumption is, that the his-

tory of humanity has been one of progress, partly by evolution under the influence of inheritance and adaptation, and partly by elaboration, or the working out of its own destiny by the conquest of nature. At times, by greater or smaller gradient, the march of favored races has been steadily onward and upward; at times it has been by tortuous paths downward towards the level of its origin; but on the whole, in certain quarters there has been elevation to knowledge, happiness, refinement and virtue.

From the analogies of nature, another set of principles have been deduced somewhat as follows: As the human fœtus passes though a series of transformations, at the different stages of which it more or less resembles the embryos of each of the groups of the animal kingdom beneath, epitomizing in its varied forms the evolution of the zoölogic world; or as the fauna and flora of the earth at any age present a comprehensive view of all preceding faunas and floras; so the *ensemble* of humanity now on the globe include, as in a rough sketch, every phase of civilization our planet has witnessed. Moreover, each particular people epitomizes all that is beneath it in culture, and the enlightened nations include within their social area every form of social, intellectual, and moral life that now exists or has ever existed on the earth.

From these fundamental propositions, hardly as yet to be called axioms, has originated the anthropological dictum, that we have only to familiarize ourselves with the tribes that now people the earth, in order to reconstruct the whole history of humanity, to put life into the dry bones of the past, disclosed in river gravels, caves, shellheaps, dolmens, mounds and graves, and to assign to its proper place and function every relic of the past.

Without disputing this theory, indeed, admitting it to be in a broad sense true, our first duty, manifestly, is to enquire what are those external and internal forces that are, under our eyes, producing changes in the races of men. Among the myriad powers and influences bearing down upon the sensitive bodies, the more sensitive spirits, the manners and groupings of men, we here single out one, commonly overlooked by those who are wont to discuss sociological themes. It is this. Just as in our day a part of the environment of a people is the juxtaposition of other peoples rejoicing in preëminence of some kind, so it has been in the past. Civilization has, no doubt, been evolved under the guiding or restraining hand of nature. It has also been elaborated by

the ingenuity and perseverance of vigorous stocks of men. But it has likewise to a large extent been borrowed. The consideration of this subject will be useful in many ways. It will serve as a check upon the excessive reliance which we have placed in the dictum that the human mind, being one, acts similarly always under similar circumstances. It will bring us somewhat nearer to the solution of several vexed problems in philosophic anthropology. But most of all it will be of practical value in devising methods for the management and the elevation of the Indians, Negroes and Chinese within our borders.

I would not be understood as denying that the same food, dress, ornament, implement, method, word, custom, or rite had originated independently in various parts of the world. But I am very sure, on the other hand, that no one would be so rash as to affirm that all similarities had arisen independently, and that a race cannot impart its peculiarities to another.

In the second place theoretical anthropology receives great aid from this subject, since it bears upon *chronology*, *reversion*, *environment*, *race*, *technics*, *language*, *social life* and *religion*.

All writers upon the philosophy of history, approaching the subject from various sides, have been careful to consider the relation of man's progress to the flight of time. With many of these writers the fashion is to argue thus. It must have taken so many centuries to learn the use of fire, so many more to invent the bow, so many more to mould the plastic clay, to exchange the skins of animals for textile fabrics, to seek shelter in artificial dwellings, to domesticate wild animals, to plant cereals, to work in metals, to preserve thought in writing, and to become organized into governments and families. If it be conceivable and possible that under favoring conditions one people were inventing the bow while another were excavating the dug-out, another spinning and weaving, and yet another elaborating ceramic industry, according as necessities, materials, implements, and natural aptitudes abounded, the whole body of speculations based on the evolutions of industries lose a part of their force. The case is similar to that which embarrasses the Egyptologists with reference to the dynasties of Manetho; the difficulty being to decide how many were simultaneous.

The overlap of sociological dynasties is authenticated in the myths of all nations respecting civilizers who came among a peo-

ple in their infancy and taught them new and better ways. Like the faults in geological structure these events give evidence of occasional leaps and cataclysms in the course of the uniformitarianism of nature. Among the well known missionaries of culture are Cadmus, Odin, Bochica, Prometheus, Manco Ccapac and Mama Oella, Hiawatha, Tezcatlipoca and Quetzalcoatl. The untutored savages stood amazed in the presence of these wonder working seers, accepting their blessed gifts, honoring them with filial reverence in their lives, and, after death, paying them divine honors. It may be that no such individuals really lived, but it cannot be denied that in their myths are wrapped up a world-wide confession that progress in civilization has been due to social influences from without, in addition to those within.

Another phase of anthropological science germane to the subject under discussion is its relation to reversion and degradation. The most abject races of men occupy the least desirable and least favored areas. No one supposes that the Eskimos, the Fuegians, the Mincopies, the Hottentot, the Australians, the Digger Indians were created where they are, or that in these dispirited creatures, this slag of humanity, we have the unaltered progeny of pristine man. They have shrunk and retreated to their present abodes before higher and more formidable groups. And this leads me to state an empiric result which may come to have the dignity of a law. The savage in the presence of a civilization too much higher than his own for him to see its desirability or to hope ever to attain it, stands his ground for a brief season and then withdraws to more inhospitable climes, following the line of least resistance in the composition and resolution of natural and social forces. In these unfriendly climes, with diminished mental and physical energy, as well as poorer and less accessible food and comfort he has changed for the worse. Has he merely reverted to his former condition, or has he degenerated and lost his way on the wastes of time? He may have descended a hill which he had previously climbed, but he has lost force, and hope, and resources, and it is impossible to say that he stands at its base near the spot where he commenced to ascend.

Upon our answer to these questions will depend somewhat the value we set upon the dictum that to study the past we have only to study the present. The amount of dispiriting influence to which lower tribes of men have been subjected in the course of their his-

tory must have materially affected their vitality and their prospects of advancement. In the struggle for existence, therefore, some races have arisen on the ruins of others, and in this process of giving way there has not been merely reversion, but degradation.

In the third place, civilization is to a great extent dependent on environment. Men are fishermen, hunters, root-eaters, etc., because nature is more bounteous to them in some one direction. Now their success in any one of these occupations may be affected by nature herself, giving more bountifully or withholding her largess, or by turning loose natural enemies. The environment may be affected by the people themselves in the wanton destruction of their means of support. This is best exemplified among modern civilized nations where the multiplication of material comforts depends upon the waste of raw material. It must not be forgotten, moreover, that the environment of a tribe or race has been time and again seriously affected by the presence of others; indeed, every people, however degraded, is both environed and environing. That charming book of Marsh's, "Man and Nature," gives numerous instances of change in the current of history by the change of surroundings through human agency. But we need not go beyond our own land for a striking example of this. Within the area of the United States, in a very few years, the question will not be, whether the Indians may hunt buffalo or other game. There will be none to hunt. The great birch trees for canoes, the root and berry wastes, the fishing grounds will all be gone or useless.

And just here I beg leave to step aside in order to call attention to the vast difference between our country and Canada in this regard. There the environment, over the greater part of the territory, has remained unchanged since Cartier visited her wastes in 1535, and the problem of the government of the Indians comparatively simple. Here, although we have not removed the plant, we have so changed the surroundings as to reduce it to the condition of an exotic. I am sure there is no one who will not agree with me that changed environment necessitates a change of treatment, and that a natural treatment must be based upon a careful study of the inorganic, organic, and social surroundings.

The next question that presents itself for our consideration is the consequences to posterity of the mutual envisagement of different

stocks of men. An easy answer would be, that new races would be formed. Dr. Daniel Wilson, of Toronto, has drawn our attention to a new style of visage, characteristically American, appearing from the mixture of the Aryan and the American Indian. Dr. Victor Havard has given us a census of these mixed bloods in the northwest. The question has been hotly contested whether the progeny of such mixtures is as fertile and vigorous as either of the parents. My time does not allow me to discuss these problems separately; but my purpose is served when I call the attention of the Association to the fact, that we need not look to the slow processes of nature for all the changes in man's physical organization in every instance, but that the mixing and blending of higher with lower has propagated in the lower the characteristics once acquired and has disseminated and perpetuated them. Much good material may be looked for in the forthcoming census report regarding this subject. Besides the Indians on reservations, there are scattered through all the states, between 70,000 and 80,000 enrolled as citizens of the United States. The enumerators have given in every instance the entire family relation of these people, including birthplace, age, blood, marital relation, posterity and occupation, and these facts will be minutely tabulated.

It is somewhat difficult to treat of *technics* aside from other social phenomena, but, inasmuch as a marked difference will be noted when we come to consider the subject in its bearing upon education, it is better to keep them apart here. The history of mankind is filled with accounts of this conflict of *technique*. The English have a grand opportunity of studying it in their East Indian empire; but one example of what I mean will do for all the world. When the Pilgrims landed at Plymouth (1620), or the first settlers at Jamestown (1607), two entirely different systems of *technique* were face to face. We may for a moment ignore the people who practised them and direct our attention to the objects themselves. Let us place the food of the English over against the food of the savage, with all the paraphernalia of its preparation; I include also narcotics and drinks. In like manner let us oppose one to another habitations and structures, clothing, adornments, weapons, implements of all industries, means of locomotion, pastimes, and methods of æsthetic enjoyment. These shall all have 250 years of contact and conflict. But we need no more than ten

years to note a remarkable change both of instrumentalities and methods. Remark, that I am here only speaking of the functional and not of the structural in sociology. Each of the classes of objects and its concomitant processes has described a curve of its own. In the matter of food there is an absolutely indifferent interchange; what pleases one pleases the other, nearly. The Englishman becomes a slave to the Indian's tobacco and the Englishman's whiskey reduces the Indian to a brute.

With respect to edifices there is little or no change, each one holding his own, borrowing here and there a few details. Almost the same may be said of clothing and ornament. Yet the ridiculous make-up of some aboriginal toilets after the advent of the whites is somewhat astounding. The substitution of blankets and prints for skins enabled the savage to change the thing without altering the process, for instruments change faster than processes.

In the means of locomotion, the savage holds his own, his snow shoes, canoes and sledges having a better adaptation to the environment than those of the whites. In other words the whites arose to the vantage ground occupied by the savages, and became as expert as they in their wild employments. In the matter of pastimes little of invasion took place from either side. But that which has interested me the most is the conflict of arms and implements. How readily the Indian gave up his stone point for a metal point to his arrow, and how quickly the most advanced tribes surrendered the bow for the rifle. They did not give up their methods however. Processes change only with change of environment and physical organization. Indeed the Englishman, while he sold the Indian his gun, borrowed and practised universally his method of skulking about and stealing on his foe. In the advance of peaceful industry the progress has been fearfully slow. I remember reading in Layard's Nineveh that, although he had taken out wheelbarrows for his Arabs at great expense, they would not push them, but took to carrying the dirt upon their heads in the wheelbarrows, the reason being, naively states the author, that "I do not believe the Arab has any wheelbarrow muscles." And this transient remark is at the bottom of all that I have been saying. If the Indian of Virginia had cultivated corn or tobacco with a bone or stone-hoe, he had no objection to substituting an iron hoe, because the process is the same. I believe the same is true of everything which the savages easily im-

bibed,—it involved no new process. It is the part of education most easily acquired, because there is everything to gain and nothing to lose in having the best of life's comforts and implements.

The influence of contact upon language has been better written up than any other division of the subject now under consideration. The idolum that speech is the most reliable mark of race, that men speak the same language because they are of the same race, has fallen before a more thorough investigation. The Bureau of Ethnology, at Washington, is organized upon the basis of language. There are over seventy radically different stock languages known to have been spoken within the area of North America. The most of these are found among little detached bands in the mountains of Washington Territory, Oregon, and California. Each of these stocks, all on the same plan of grammatic structure, is a result, a residuum, first, of that system of laws by which a language is perpetuated among a people, and second, of that process of modification by contact which languages in conflict invariably undergo. The examples are numerous within the historic period of a people surrendering their vocabulary and even their grammar in the presence of a more powerful or a more intelligent neighbor or adversary. Along the track of human development the thoughtful student, pursuing his way, halts at almost every milestone to witness the conflict of tribes and races, a conflict that does not end with battle, nor with extermination. (There never was a people exterminated in that way.) The victor in arms is vanquished in his industries, his language, or his social system. The old story of the Ottoman Turks, sweeping down from their northern plateaus upon the Mohammedans of the Tigro-Euphrates valley and annihilating them tribally, but yielding to their language and religion, has been repeated on nearly every portion of the habitable globe. It is as though we were looking through a huge kaleidoscope. Here are bits of glass called Aryan, Semitic, Ugrian. By a single revolution of events there appears the wonderful mosaic of peoples inhabitating western Asia and eastern Europe at the beginning of the Christian era. The philosophic historians of that day have preserved the forms and colors of this beautiful picture. By another turn of the kaleidoscope Rome is conquered by hordes of Goths, Celts and Slaves. The hordes received letters and the Christian religion. Rome, that had received the religion of Judæa captured and enthralled, now

surrenders her political ascendancy to become the Jerusalem of Christendom. Even the terms of her capitulation and disgrace were handled down to posterity in her own language by her captors.

From the marriage of this youngest and fairest daughter of Rome, the language of Cicero and Virgil, with the jargons of her conquerors sprung the Neo-Latin tongues. In like manner on other soils have races confronted one another with strange methods and machinery, and from the encounter have saved all tha. was vigorous in each. After this manner it is possible that the drama of civilization has been enacted many times over, as the inexplicable ruins in many places now inhabited by ruder peoples attest.

We come lastly to speak of the structural and regulative phases of society. In almost every department of nature we notice how much less flexible structure is than function, how far law is behind practice. Notice the five civilized tribes of Indians in the Indian Territory. They have run the whole gamut of civilization, occupying in many things its highest rounds. They have all the paraphernalia of our food, dress, habitation, technique, everything material; but they retain their language, social organization and system of Indian philosophy. Is it not passing strange to hear a hymn to the Semitic Jehovah in an American Indian tongue, set to the Aryan chromatic scale, sung by men and women of totemic clans, dressed in English costume, living as a foreign treaty power within the territory of the United States? Yet it is easy to separate these incongruities. The Indians have given up the functional, they retain the structural, they abandon the operative, they hold on with the death grip to their regulative system. It is folly to suppose that savages should comprehend at a glance or in a generation those principles of civil, political and religious liberty which have cost ages of conflict and suffering, millions of treasure, which have absorbed the choicest minds of all ages, and which are not comprehended by a tithe of our own people. I have said sufficient upon this theoretical portion to come at once to that which is practical.

Although a caution was sounded in the first part of this paper against confounding things simultaneous with those which are necessarily successive, it was by no means intended to be affirmed that there are no grades, no necessary lines of advancement in culture. Just as the meridians of longitude, extending from the

pole to the equator pass over the habitat of every animal and plant on the globe, so do the regulative and operative, structural and functional elements of civilization lie along a line of historic evolution. Again, just as the meridians are crossed by a system of isothermal lines, so may the student of sociology pass across the categories of culture, following those steps in development which are contemporaneous. In technical terms the lines of successiveness in the various phases of civilization are crossed by lines of simultaneity. No civilized nation of ancient or modern times has paid any attention to these facts in the treatment of aboriginal populations. In the experiments which have been made since the opening of the sixteenth century it would be singular if something had not been learned in the midst of a host of failures. The proper consideration of the relation existing between the simultaneous and the successive will be of immense importance in dealing with our own aborigines.

In many of our school text-books mankind are divided into savage, barbarous, half-civilized, civilized, and enlightened, five degrees of successiveness.

Mr. Lewis H. Morgan, in his "Ancient Society," recognizes seven: Lower status of savagery, middle status of savagery, upper status of savagery, lower status of barbarism, middle status of barbarism, upper status of barbarism, status of civilization. The steps in this succession are marked by some new and important invention. Mr. Morgan does not attempt to classify scientifically the phenomena that are simultaneous.

Mr. Herbert Spencer, in his "Atlases of Descriptive Sociology," has most elaborately classified the phenomena of culture, in columns indicating simultaneity, and has traced historically in each column events in succession; but he has not attempted to connect events in the various columns by lines of simultaneity indicating grades of civilization. Suffice it to say then, there are necessary gradations, degrees, steps, stages of human progress. Let us designate them by the letters of the alphabet, the first denoting the lowest degree. It would seem to need no proof that it is easier to pass from A to B, than from A to C, just as varieties are fertile in proportion to their similarity of structure.

If there are seven stages, and our Indians occupy III, IV, and V, there are at least two stages between the highest and the best among us, and four between the lowest. Of course, there are

vagabonds in our system lower than the lowest savage, or at least no higher. Unfortunately it is this element which by a species of social gravitation first seeks the aboriginal society, and it is with it that the savages mingle most kindly.

The whole system of education on our continent, Protestant and Catholic, French, English and Spanish, with rare exceptions, has proceeded upon the theory that the middle steps could be ignored entirely, and that the structure of society could be changed as easily as its functions, its regulative phases as easily as its operative.

I do not mean to question the sincerity, the self-denying zeal of those who were engaged in these enterprises. Nevertheless the sufferings and privations of the Jesuits in New France, the holy devotion of Eliot and his colleagues, the calm perseverance of the Quakers and the Moravians, the barren enthusiasm of Las Casas and his successors, are all stamped with the condemnation of "zeal without knowledge."

The patrons of these benevolent schemes have been popes, the sovereigns of France, Spain and England, societies for the propagation of the gospel, the United States government, state governments, endowed colleges, wealthy men and women, at home and abroad, and to a very large extent the Indians themselves in their treaty funds.

The agents have been Catholic fathers and nuns, Protestant ministers of every denomination, teachers in secular and government schools, both white and native. Millions of money have been spent, hundreds of noble lives have been sacrificed, and yet the result has fallen far short of the outlay. The five civilized tribes of Indian territory, the Iroquois of New York, and some Chippewa tribes of the northwest are the only fruits of the old regime. It will be a most instructive chapter in sociology which recounts the methods by which these beneficent ends have been achieved. The colleges, schools, and older institutions engaged, have now nearly abandoned the field to the government. A few paragraphs from the early efforts to educate Indians may not be amiss.[1]

The Spanish, in the sixteenth century, established an "Indian College" at Havana, to which a number of boys were sent from Florida, but all record of the result is lost. An Indian youth of Virginia, baptized Don Luis de Velasco, was captured and carried

[1] Most of these notices were compiled for Major J. W. Powell, by Col. I. N. Clarke.

to Mexico, and afterwards to Spain. He was an intelligent man, thoroughly conversant with Spanish affairs. He returned in 1570 to Virginia with Father Segura and his little band of Jesuit missionaries. Once again in his native woods, Don Luis returned to savagery and murdered the band of missionaries. Melendez visited the scene of the transaction and hanged several of the abettors of the murder; but Don Luis escaped, and thus disappeared the first christianized and educated North American Indian, and the first and only effort of the Spaniards to form a settlement within the limits of the state of Virginia.

The seminary begun at Quebec in 1668, by Laval, was designed for both French and Indians, having at first eight French and six Indian scholars. Parkman says of the Indian boys sent here: "Sooner or later they all ran wild in the woods, carrying with them as fruits of their studies a sufficiency of prayers, offices and chants learned by note, along with a feeble smattering of Latin and rhetoric, which they soon dropped by the way (Old Regime, etc., p. 163)." The Documentary History of New York gives numerous efforts of both the French and English to educate Indian youths. The Virginia colony in 1612 endeavored to civilize the Indians by encouraging intermarriage with the whites, and forty or fifty of such unions are recorded.

Lord Delaware sent a boy named Nanarvack to England to be educated, but the experiment failed by the death of the youth. In 1616, Sir Thomas Dale carried divers men and women to England to be educated. Thomas Rolfe, the son of Pocahontas, was educated by his uncle in England, and returned to Virginia. He lived with the whites altogether. Other efforts were made to carry Indian boys to England, but I cannot learn that success attended any of them. By the Assembly of Virginia in 1619, a year before the landing of the Pilgrims, a law was enacted for the education of the native children. In 1618, however, the Henrico College was founded, but the tomahawk brought it to an untimely end after many hundreds of pounds sterling had been expended on it.

In 1691, the Hon. Robert Boyle died leaving in his will £5,400, the income of which was to be paid to the authorities of William and Mary College in Virginia, to keep at the said college so many Indian children in sickness and health, in meat, drink, washing, lodging, clothes, medicine, books, and education. The school probably begun in 1700, and from that time to the Revolution, eight to ten Indians were annually maintained and educated. The

testimony of many of the writers of that time is to the effect that after they returned home, they relapsed into infidelity and barbarism.

The Rev. Hugh Jones (London, 1724) writes: "The Indians who are upon Mr. Boyle's fund, have now a handsome apartment for themselves and their master near the college. Hitherto little good has been done them, though abundance of money has been laid out, and a great many endeavors have been used, and much pains taken for that purpose. The young Indians, procured from the tributary or foreign nations with much difficulty, were formerly boarded and lodged in town, where abundance of them used to die, either through sickness, change of provisions, or mode of life."

Mr. William Byrd of Westover laments the bad success of Boyle's charity, even charging that the knowledge acquired had been used against their benefactors. Colonel Spottiswood demanded of each nation in Virginia a competent number of their great men's children to be sent to the college, where they served as hostages for the good behavior of the rest. He also placed a schoolmaster among the Saponi Indians, at a salary of £50 per annum to instruct their children. He was, however, removed to William and Mary College, and the pains he had taken had no other effect than to make them something cleanlier than other Indians.

In 1744 an Indian orator replied to the British Commissioners interceding for William and Mary College, "Several of our young men were formerly brought up in the colleges of your northern provinces, but when they came back they were bad runners, ignorant of the means of living in the woods, unable to bear cold or hunger, knew neither how to build a cabin, take a deer, nor kill an enemy, and spoke our language imperfectly. We are nevertheless obliged to you, and if the gentlemen will send a dozen of their sons, we will take great care of their education, and make men of them." Of the ten graduates given nothing is known.

The first royal charter of the Massachusetts Bay Colony (1628), and the first letter of instructions of Governor Craddock to the leader of the Colony (Feb. 16, 1628–9), contained provisions for Indian education. In 1646 Eliot began to preach to the natives, and a son of Waban, one of their chiefs was being educated in an English school at Dedham. Eliot had a tract of land laid off at Nonantum, and the Indians were supplied by public aid with agri-

cultural implements, as well as taught to construct walls, ditches, houses, to engage in agriculture, and to learn trades. The women were taught to spin. And even forms of jurisprudence were established among them. In 1649 the Society for the propagation of the Gospel in New England was established and a fund yielding 500 to 600 pounds a year was realized. In 1651 the settlement was moved from Nonantum to Natick, the oldest of the fourteen praying towns, prior to Philip's war.

In 1656 the Society paid £135 for the tuition, etc., of nine boys and one girl in Mr. Weld's school.

In the charter of Harvard College, 1650, one object is stated to be the education of the English and Indian youth of this country in knowledge and godliness. Gookin describes the building as it existed in 1674 (Mass. Hist. Coll., I, 176). The records of the Commissioners for 1656–64 contain detailed accounts of money expended for Indian education, footing up £5,830 for ten years. The majority of the teachers after 1660 appear to have been natives. In 1687 there were 24 native preachers in New England. Of some of these very unfavorable accounts were given. The efforts to qualify them for interpreters and schoolmasters were partially successful, but those made to fit them for higher walks of life failed, and numbers of them sickened and died. An Indian printer is mentioned in connection with the preparation of Eliot's Bible. Boyle and Williams made bequests to Harvard for Indian education.

In 1734 the New England Commissioners of the Society for the Propagation of the Gospel offered £100 a year for a missionary to the Housatonics at Stockbridge, and Mr. John Sergeant, a tutor in Yale undertook the mission. The Indians welcomed him and built him a school-house. The success of this industrial school would well repay perusal but time forbids. It is interesting to know that Mr. Sergeant was succeeded by the Rev. Jonathan Edwards.

The same year (1754) that the school at Stockbridge was discontinued, the Rev. Eleazer Wheelock began at Lebanon, Connecticut, a school for the education of Indian youth that was the germ from which Dartmouth college sprang. But it will not be possible to enter into the details here. I shall endeavor to ascertain the history and result of all these early enterprises.

The American Board of Commissioners commenced their efforts to civilize and evangelize the Indians in 1817 by the establishment

of a school at Cornwall, Conn., and the settlement of missionaries among the Cherokees. Their charter reads, "the education in our own country of heathen youths so as to qualify them for missionaries, physicians, surgeons, school-masters, and interpreters, and to communicate to the heathen nations such knowledge in agriculture and the arts as may prove the means of promoting christianity and civilization. The Cornwall school was very like that at Carlisle. To the credit of the Christian denomination which had it in charge it must be said that everything that could be done was done for this school in the way of equipments, the selection of the youth, the course of study, industrial training, spiritual and moral influence, and the choice of teachers. Nor were sympathy and money wanting.

After seven years the Board became embarrassed with the question, what to do with their pupils after graduation. Let them speak for themselves. "Though some of the pupils may render valuable aid to missionaries, experience seems to indicate that youths educated upon missionary ground are most apt to be fitted for the various circumstances of a residence among their countrymen, than those who have been accustomed to a different manner of life." In 1825, two years later, "The indications of Providence seem to teach that the best education of youths born heathen, having reference to their success as teachers of their brethren, must be given through the instrumentality of missionary institutions in their respective countries." A committee, of which Jeremiah Evarts, father of the late Secretary, was a member, was appointed to examine the Cornwall Academy. Their report is a most wonderful production for 1826. The school was closed in 1827. The secret of this failure is briefly told. Few of the pupils comprehended what the Board were driving at. Those who did not returned, having lost the vigor and skill of Indian life and devoid of those qualities which give the white man success. They became the pariahs of their tribe, or vagabonds in white settlements. Those who acquired some little apprehension of our culture were at a double disadvantage. They were regarded as deserters and renegades at home, and race prejudice as well as want of skill debarred them of success among white communities.

In 1826 the Choctaw Academy was established at Great Crossing, Kentucky, at the request of the Indians themselves. A large majority of the pupils were Cherokees, Creeks, Choctaws

and Seminoles, from whom, in their former homes, it was not distant. After sixteen years it was discontinued, having cost the Indians nearly half a million dollars.

At present, and for some years past, the education of our Indians has undergone a great change. It may be divided into two kinds, industrial and literary. By industrial education I mean, the employment of carpenters, herders, farmers, and skilled workmen of other crafts to labor among the Indians, binding the tribe in the treaty to furnish a certain number of apprentices, and stipulating to give the preference to skilled Indians when it shall become practicable. By literary education I mean the establishment of camp schools, day schools, boarding schools, and the payment of tuition for the support of Indian youths in the schools and colleges for whites. The method from which the Indian Bureau, as well as the Catholic and Protestant teachers, look for the best results, is the Industrial Boarding and Day School, on the Reservations. Of these last there were during the census year sixty already established. I except the three training schools at Carlisle, Hampton and Forest Grove, which are all a return to the old methods of the last century, excepting that the home environment to which the pupils return is very much improved, indeed, in many cases, so changed as to give a new aspect to the problem altogether.

The annual cost of these institutions cannot be ascertained. The government appropriates between four and five millions annually for the Indian Department. These appropriations are of three kinds: interest on stocks held by the United States for the tribe, and interest on tribal fund deposited in the Treasury at five per cent.; annuities fulfilling treaties; and gratuities. The various religious denominations are expending a great deal of money for the civilization of the Indians, and some of the tribes are appropriating a large share of their annuities for schools and for the care of the destitute.[2]

[2] The Report of the Commissioner of Indian Affairs for 1880 gives the following summary. "For the five civilized tribes: boarding schools, 12; day schools, 212; attendance, 6,098; tribal fund expended, $186,359, by government, $3,500; can read, 34,550. For other tribes: boarding schools, 60; day schools, 109; accommodations, boarding, 3,859, day, 6,113; children of school age, 34,541; male teachers, 126; female, 212; attendance, 7240; can read, 11,780. Expended by government, $249,299; by Indians, tribal funds, $7.481; by New York, $15,853; by Pennsylvania, $325; by religious societies, $46,933." The total appropriation was $4,674,573.44, of which nearly a million and three quarters are gratuities, that are not provided for in treaties. To this must be added the vast expense to the government of the military employed in the Indian service.

From these reflections, already too extended, I desire to draw a few conclusions.

1. The science of anthropology has paved the way to an economical and wise system of education for lower races of men by pointing out the elements of civilization and the order of their normal evolution. The Bureau of Ethnology at Washington, under the management of Major Powell, has already begun to bear fruit in this direction.

2. Mr. Herbert Spencer, in his Descriptive Sociology, has furnished us with an analysis of culture by a judicious application of which we may unravel the mystery of the education of savages. There we have the regulative aspects of society separated from the operative, the structural from the functional. We have already seen that function yields much more readily to external influences than structure, and that the operative classes of society, together with their methods and implements, change with greater facility than the regulative. The simpler operations and functions may be altered with less violence than the more complex.

3. The practical lessons of Indian and Negro education are therefore working themselves out according to the laws of nature and of human action. The instruction we offer them is like the food we eat, that which is adapted to their nourishment remains, the rest is rejected; and this applies to the propagation of vice and disease as well as to virtues and industries.

4. I am therefore bound to close this paper with a word of caution to those who despair of saving these lower tribes of our kindred, as well as to those sentimentalists who would pamper a few of them by a splendid but misguided charity. To the former I would say, the problem of their salvation is already being worked out with the civilized tribes, with the 70,000 enrolled as citizens of the United States, and with a goodly number already self-supporting on our reservations. To the second it is necessary to suggest that any education is bad which unfits the recipient for the environment in which he is destined to live, and that the wholesale imputation of wrong done to the Indians by the government and people of the United States is as gratuitous as it is mischievous.

TITLES OF OTHER PAPERS READ BEFORE THE SUB-SECTION OF ANTHROPOLOGY.

THE STONE IMAGES AND IDOLS OF THE MOUND-BUILDERS. By William McAdams, of Otterville, Ill.

SOME REMARKABLE RELICS FROM MOUNDS IN ILLINOIS. By William McAdams, of Otterville, Ill.

STONE IMPLEMENT SHOWING GLACIER MARKS. By William McAdams, of Otterville, Ill.

MOUND-BUILDERS' SKELETONS. By Watson C. Holbrook, of Coleta, Ill.

STONE IMPLEMENTS IN THE DRIFT. By Watson C. Holbrook, of Coleta, Ill.

PREHISTORIC HIEROGLYPHICS. By Watson C. Holbrook, of Coleta, Ill.

ON THE INHABITANTS OF NORTHEASTERN SIBERIA, COMMONLY CALLED CHUKCHIS AND NAMOLLO.[1] By W. H. Dall, of Washington, D. C.

ILEX CASSINE, THE BLACK DRINK OF THE SOUTHERN INDIANS. By John G. Henderson, of Winchester, Ill.

WAS THE ANTELOPE HUNTED BY THE INDIANS ON THE PRAIRIES OF ILLINOIS? By John G. Henderson, of Winchester, Ill.

AGRICULTURE AND THE AGRICULTURAL IMPLEMENTS OF THE ANCIENT INHABITANTS OF THE MISSISSIPPI VALLEY. By John G. Henderson, of Winchester, Ill.

HOUSES OF THE ANCIENT INHABITANTS OF THE MISSISSIPPI VALLEY. By John G. Henderson, of Winchester, Ill.

[1] This paper is printed in the American Naturalist for Nov., 1881.

EXHIBITION OF SOME ARCHÆOLOGICAL SPECIMENS FROM MISSOURI. By S. H. Trowbridge, of Glasgow, Mo.

ON THE INTERPRETATION OF PICTOGRAPHS BY THE APPLICATION OF GESTURE-SIGNS. By W. J. Hoffman, of Washington, D. C.

COMPARISON OF MAYA DATES WITH THOSE OF THE CHRISTIAN ERA. By Cyrus Thomas, of Washington, D. C.

THE TEMPORAL PROCESS OF THE MALAR BONE IN THE ANCIENT HUMAN CRANIA FROM MADISONVILLE.[2] By Frank W. Langdon, of Cincinnati, Ohio.

THE EMBLEMATIC MOUNDS ON THE FOUR LAKES OF WISCONSIN. By Stephen D. Peet, of Clinton, Wis.

EXHIBITION OF A CURIOUS STONE RELIC. By G. W. Holstein, of Belvidere, N. J.

ANTIQUITY OF MAN IN AMERICA. By W. De Hass, of Washington, D. C.

PROGRESS OF ARCHÆOLOGICAL RESEARCH. By W. De Hass, of Washington, D. C.

THE MOUND BUILDERS. AN INQUIRY INTO THEIR ASSUMED SOUTHERN ORIGIN. By W. De Hass, of Washington, D. C.

[2] Printed in the Journal of the Cincinnati Society of Natural History, Vol. IV, No. 3, Oct., 1881.

EXECUTIVE PROCEEDINGS.

REPORT OF THE GENERAL SECRETARY.

Wednesday, August 17, 1881.— The thirtieth meeting of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE was called to order in Music Hall, Exposition Buildings, Cincinnati, at half-past ten o'clock, by Prof. GEORGE J. BRUSH, of New Haven, Ct., the President of the Cincinnati meeting. In opening the exercises he remarked that it was customary for the retiring President to fulfil that pleasant duty, but as the Hon. L. H. MORGAN, of Rochester, N. Y., was absent, it devolved upon him, and he would do so by first reading a letter addressed to the meeting by the retiring President, as follows:—

ROCHESTER, Aug. 15, 1881.

MY DEAR MR. PRESIDENT:

I have waited until now about deciding not to attend the coming meeting of the Association at Cincinnati. It is with great reluctance that I have finally concluded that it will not be prudent for me to attend. I think I might bear the fatigue, but taken in connection with the probable hot weather, I should be afraid to undertake it.

The duties devolving upon the retiring President are very slight as well as pleasant in their performance, and it requires some degree of self denial to withhold myself; but there is no discredit in being able to recognize the fact that my time for labor has passed. Beside, the advice of my physician is imperative.

It is with a pang of regret that I thus bid adieu[1] to the meetings of the Association which have been such a source of delight for so many years.

Wishing you a very pleasant and successful meeting at Cincinnati,

I am, yours truly,

L. H. MORGAN.

President BRUSH followed this communication with a few appropriate remarks, and in closing said:

Accept my grateful thanks for the honor you have conferred upon me in electing me to preside over your deliberations. It will be my earnest endeavor, with your coöperation, to maintain the high scientific character which this Association has so long enjoyed. Let us work cordially together to make this second gathering in Cincinnati worthy of the city in which we meet, and of the sciences we so earnestly labor to advance.

The proceedings were then formally opened with prayer by the Rev. Dr. RIDGAWAY, of Cincinnati.

[1] These sad words proved only too prophetic. After a lingering illness Mr. Morgan died on December 17.— F. W. P.

The Hon. J. D. Cox, on behalf of the local Executive Committee, then welcomed the Association, and spoke as follows:

Mr. President, and Members of the Association: — The Local Committee have assigned me the pleasant duty of welcoming you to Cincinnati, and I can assure you the welcome is a most hearty one from all classes of our citizens. The apprehension of a great public grief has perhaps sobered the feelings with which both you and we enter upon what we would gladly give something of the air of a festivity, but the better news we get to-day from Washington restores our cheerfulness if it does not wholly remove our fears, and we trust the reunion of the Association here may be a joyous occasion to all.

The claims of science to public recognition are not now looked upon as doubtful. The whole community feels the indebtedness it owes to scientific investigation and discovery. When the Association in its infancy met in Cincinnati, many years ago, it was in the infancy of the city also. What a wonderful change has come since then! What was scarcely more than a country village has grown to be a great city, a manufacturing centre for a large extent of country and one of the important mercantile marts of the world. Beyond us, in what was then an almost unbroken wilderness, other great cities have sprung up surpassing us in size and importance, and even more phenomenal in their rapidity of growth.

It would be quite fair, sir, to say that this wonderful progress would not have occurred except for the labors and triumphs of the scientific world whose representatives you are. This period is the period of the development of the railway, the magnetic telegraph, the ocean steamship, the telephone, the new process of making steel, the electric light! But for these the wilderness would have remained unbroken, and civilization would have encroached but slowly upon the domain of the savage and the range of the buffalo. Science has broken down the barriers of mountain and removed the obstacles of great distance, and has thus made possible the transformation you see, and at which the world has not yet tired of wondering.

Our people know this so well that every artisan joins in our welcome to you, and every merchant greets you as a body of public benefactors. You are welcomed by those who look chiefly to the material and economic advantages which have come from scientific work; you are welcomed by those who have learned to honor intellectual investigation for its own sake; you are welcomed also by those who have gone still farther, and who, in earnest sympathy with the progress of man, see in Science, in Art, and in Faith, the great Trinity of forces which lifts mankind nearer to its ideal.

These three points of view are all necessary to a full understanding of the relations of scientific work, and I trust I may be pardoned for enlarging a moment upon each.

The economic results of scientific investigation are, in our day, so patent that no one can overlook them, and they are, therefore, those which are most often mentioned. No machine shop is so rude that its processes do not bear witness to the application of research in physics; no factory of

tarch or soap that is not dependent on chemical discovery for its profits. n these days, when, as is often jocosely said, every brewer keeps his chemst, it is superfluous to dwell upon the benefits which every department of ndustry gathers from the work done in the laboratory and in the study.

I am sure, however, that I shall not be mistaken in affirming that you, adies and gentlemen, will agree with me in thinking that notwithstanding ll the material and economic advantages to which I have referred, the obler view to take of science is that which looks at it as the pursuit of nowledge for its own sake. The true scientific spirit is that which is aborbed in the insatiable desire to know, and which does not stop to inquire vhat material advantages are to come of investigation. It does not desise these, but it would, all the same, continue its quest after truth if no romise or dream of gain appeared at the end of a long vista of laborious esearch. To add to the sum of knowledge, to see farther into space han any have seen before, to penetrate more profoundly into the secrets of the universe than others have gone,—these are the things which excite he true student with a quenchless thirst stronger than the lust for gold, nd give a joy to conquest that neither power nor wealth can match. In his hunt after truth the hunting propensity innate in man finds its noblest ield, and by as much as the intellect and its aims are superior to the body nd its appetites, by so much is the pursuit of science for its own sake nore satisfying and exalting than to follow it only for its material rewards.

But Science is not the only domain of truth. Art has its principles, and 'aith seeks to harmonize all with the Infinite, and to bring all the proucts of both science and art into such relations to an ideal moral governnent, present and future, as shall open to man a career worthy of his aculties, and boundless as his aspirations. Pardon me, Mr. President, f I suggest that the one danger which seems most to beset scientific ninds, and one which seems sometimes to overcome them, is that of takng the narrow view which assumes that nothing may be known, except vhat is reached by the methods of the strict sciences. I think we ought o remember that the canons of art are not deduced from axioms, but in ome sort grow within us by contemplating things of beauty. A refined nd cultivated mind pronounces its judgments, *ex cathedra*, as it were, ut yet with confidence that other minds of equal culture will accord with t. All we can say of it is, that our nature is in fact so constituted that he sense of beauty, of proportion, of melody and harmony, become keener nd more sure with increased experience of things beautiful and harmoniuus. As we cannot apply other methods to this realm, we take the sponaneous judgment of a refined mind as its own warrant for its truth, nd bow to its decision.

If we look curiously into our mental processes, we are surprised to find ow soon, even in scientific reasoning, we reach the point where we must ake something for granted,—where the limit of observation is reached, nd we stand on the shore of the shoreless, the margin of the boundless! I know nothing more productive of wonder than to watch the forming of rystals in some pellucid fluid. To me it is an ever recurring mystery

which never loses its novelty or its force. Why the invisible particles of this solution should arrange themselves into a solid with one invariable law as to angular form, and the particles of that into another, is a question which always makes me feel as if an immeasurable abyss had opened at my feet. The phenomena are wonderfully beautiful, the conclusions drawn from them are overflowing with interest and fruitful in practical results; but how vain are all our efforts to pass beyond the phenomena, or by any method which we call scientific, to reach the substance without which the phenomena would be meaningless phantasmagoria! How dumb the scientist stands before the child who asks *why* the crystals are formed!

But even in the very steps which we treat as most strictly scientific, and in the strictest of sciences, the mathematical, we find ourselves in a similar way confronted with the necessity of assuming the truth of mental affirmations, fundamental to our process, but for which we can give no authority but that they are. I will not speak of the axioms of causation, of space, of time, I will refer only to memory, that mysterious faculty, without which the passage from your premises to your conclusion could never be bridged in the simplest syllogism, and the laborious induction from multitudes of phenomena would fall utterly to ruin without connection or result. How do you know that your major or minor premise is true? By the memory of a former process. But how do you know that your memory affirms truly? No answer is possible except that I spontaneously trust the *dicta* of this faculty as the necessary condition of all intellectual processes whatsoever. And so, in whatever direction we explore, our pride in our methods finds quick rebuke, and we are brought to see that the science of the philosopher has neither foundation nor connection, except as it is built upon the faith of the little child. This is quite as true when we are dealing with propositions which the great German philosopher attributed to the practical, as with those which he ascribed to the pure reason.

My only purpose in these remarks is to emphasize the importance of avoiding sweeping negations, and of allowing to every department of human intelligence its own methods and postulates. Man's advancement is only satisfactory when it is symmetrical. All his faculties and all his good tendencies must be cultivated if we would approach the ideal man. Science, Philosophy, Æsthetics, Ethics, Religion, all are fields for his activity and his growth, and broad learning will acknowledge this and admit, nay insist, that each shall be respected in its domain. Our general faith in the consistency of all finite experience, when rightly understood, makes us believe that seeming inconsistencies in phenomena will ultimately be explained in accordance with established law. A similar wisdom should make us have equal faith that in realms of thought which transcend the methods of physical science, truth will be found consistent with itself and with all other truth, and that seeming antagonism will vanish with the widening of our knowledge. For science I claim the right to follow strictly scientific methods without other let or hindrance than that which cautious wisdom will impose upon itself as a guard against hasty conclusions

drawn from a too narrow range of induction. Let us be satisfied to claim no less for Art, for Morals and for Religion; so that our idea of symmetric cultivation may be freely realized in the best and broadest sense, and the highest growth in each be found not merely consistent with, but necessary to make up the fully developed and well proportioned man.

But I am travelling farther than I meant. I will close, Mr. President, by saying that, in this as in every civilized community, you will find those who look upon learning from the several points of view I have indicated, and that the citizens of Cincinnati, whether they regard Science as the basis of material prosperity, as a glorious field to be cultivated for its own sake, or as a harmonious part of human growth and progress towards the ideal, all unite in a sincere and hearty welcome to the Association, and bid you God speed in your work.

President BRUSH responded in the following words:—

On behalf of the American Association, I thank you, sir, for your eloquent and cordial words of welcome, and for the generous and hospitable arrangements your Local Committee have made for our comfort and entertainment at this meeting.

In accepting your invitation to assemble in Cincinnati for a second time, after the lapse of a generation, we know that we come to a community in full sympathy with the objects of our Association; for, long before our first meeting here, you had in your city men of science eminent for their investigations in archæology and astronomy, in geology and other departments of natural history, so that science may be said to have had a home here, almost from your earliest settlement.

It was to be expected that as your state is a rich storehouse of treasures for the archæologist, attention should be early called to this field of investigation, and likewise, that your rocks, filled as they are, with wonderful remains of palæozoic life, should find enthusiastic explorers.

To members of this Association, however, the most remarkable evidence of your appreciation of abstract science, and of the liberality and intelligence of your people is, that almost forty years ago you should have founded and endowed an Astronomical Observatory.

This observatory, through the genius of its gifted director, became at once favorably known wherever astronomical science was studied, and it is a most interesting circumstance in its history that methods of observation, here originated and first developed, were adopted by all the leading observatories of the world.

This is indeed a proud record for your city. We congratulate you also on your marvellous prosperity and material advancement. We rejoice with you on the growth of your University, and your other scientific and literary institutions during the past thirty years, and we trust our meeting here may encourage and stimulate your citizens to new efforts for their further development.

The aim of the American Association, meeting as it does from year to year in different places, is not only to advance science by making public the results of the investigations of its members, but to cultivate social

and friendly relations between scientists throughout the whole country. Above all we desire to gather in and encourage young investigators.

Our discussions in the main are not of a popular character, and perhaps the practical bearing of the facts presented will not always be obvious to a popular audience, but nevertheless I feel that in a community where science has been so long and so generously fostered, it is no mere form for me to invite you, and through you all your fellow citizens who are interested in our proceedings, to attend and take part in our daily sessions.

Again, I thank you most heartily.

The PRESIDENT then announced the action of the Standing Committee in reference to Vice Presidents, and Prof. WILLIAM HARKNESS, of the U. S. Naval Observatory, Washington, D. C., was thereupon elected Vice President of Section A, in place of Professor MAYER, absent on account of sickness, and Prof. E. T. COX, as Vice President of Section B, in place of Dr. GEO. ENGELMANN, of St. Louis, who had declined, owing to expected absence in Europe.

The PERMANENT SECRETARY then announced that notices of the decease of the following seventeen members of the Association, including a past President, had been received since the last meeting.

CHARLES T. JACKSON, of Boston, Mass. An original member of the Association. He was born June 21, 1805, and died during the Boston meeting, Aug. 29, 1880.

S. S. HALDEMAN, of Chickies, Penn. An original member. Born Aug. 12, 1812. Died Sept. 17, 1880.

LEONARD CASE, of Cleveland, Ohio. Joined at the 15th meeting. Born 1820. Died 1880.

E. P. DORR, of Buffalo, N. Y. Joined at the 25th meeting. Died March 28, 1881.

GEORGE B. EMERSON, of Boston, Mass. An original member of the Association. Born Sept. 17, 1797. Died March 4, 1881.

JAMES H. JONES, of Boston, Mass. Joined at the 28th meeting.

W. K. KEDZIE, of Oberlin, Ohio. Joined at the 25th meeting.

JOHN B. MAUDE, of St. Louis, Mo. Joined at the 27th meeting. Died April, 1879.

JAMES AITKEN MEIGS, of Philadelphia, Pa. Joined at the 12th meeting. Born July 31, 1809. Died Nov. 9, 1879.

WILLIAM MINIFIE, of Baltimore, Md. Joined at the 12th meeting. Born in 1805. Died Oct. 24, 1880.

JOHN B. MORRIS, of Nashville, Tenn. Joined at the 26th meeting.

JOHN NEWLAND, of Saratoga Springs, N. Y. Joined at the 28th meeting. Died Jan. 18, 1880.

GEORGE A. OTIS, of Washington, D. C. Joined at the 10th meeting. Born Nov. 12, 1830. Died Feb. 23, 1881.

BENJAMIN PEIRCE, of Cambridge, Mass. An original member, and a President of the Association. Born April 4, 1809. Died Oct. 6, 1880.

SAMUEL WATKINS, of Nashville, Tenn. Joined at the 26th meeting.

ARTHUR W. WHEELER, of Baltimore, Md. Joined at the 29th meeting. Born March, 1859. Died Jan. 6, 1881.

SAMUEL S. WHITE, of Philadelphia, Pa. Joined at the 23d meeting. Died Dec. 30, 1879.

The STANDING COMMITTEE was then completed by the election of the following six Fellows: E. S. MORSE, of Cambridge, F. W. CLARKE, of Cincinnati, A. H. TUTTLE, of Columbus, W. H. DALL, of Washington, H. C. BOLTON, of Hartford, T. C. MENDENHALL, of Columbus.

The GENERAL SECRETARY, pending the above balloting, read a list of 222 persons recommended to membership by the STANDING COMMITTEE, and they were duly elected.

Prof. F. W. CLARKE announced that the scientific exhibit of the Ninth Industrial Exposition of Cincinnati would be opened to the members of the Association after 1 o'clock in the afternoon, and on every following day of the meeting from 9 A. M. to 6 P. M.

Various announcements were made by the LOCAL SECRETARY, followed by the reading of several notices by the GENERAL SECRETARY, of a letter from Principal DAWSON of McGill College, Montreal, excusing his enforced absence, and suggesting Montreal as the next place of meeting, and one from Prof. A. M. MAYER, of South Orange, N. J., regretting his absence on account of sickness.

The General Session then adjourned to meet in sections.

Thursday, August 18, 1881.—The Association convened in Power Hall, Exposition Buildings. President BRUSH called the General Session to order at 10 A. M.

Letters extending hospitalities to the Members of the Association were read by the GENERAL SECRETARY from the following:

Young Men's Christian Association, cor. Sixth and Elm streets, W. MCALPIN, *President;* University Club, E. R. DONOHUE, *Cor. Sec.;* Public Library of Cincinnati, W. H. MUSSEY, *Pres't Board of Managers*, CHESTER W. MERRILL, *Librarian;* Cuvier Club, No. 200 4th street, between Elm and Plum streets, JOHN W. CALDWELL, in behalf of *Cuvier Club;* Cincinnati Chamber of Commerce and Merchants Exchange, H. C. URNER, *President.*

The GENERAL SECRETARY read the names of 53 persons whose names were recommended to membership by the STANDING COMMITTEE, making in all 275, and they were duly elected.

The Session then adjourned to meet in sections.

Friday, August 19, 1881.—At 10.30 A. M. President BRUSH called the General Session to order.

Mr. McAlpin announced that an excursion to the Zoölogical Garden had been arranged for Saturday afternoon, and requested those who desired to attend to register their names with the Secretary. The admission to the Garden would be free to members, and a free lunch would be served at the restaurant in the Garden.

A telegram of congratulation was read from the Photographers' Association, now in convention at Saratoga, N. Y., and a suitable reply ordered.

The Permanent Secretary stated that two subscriptions had already been received to the amount of $105, for the purpose of reprinting certain volumes of the Proceedings, now out of print, and that the fund needed was about $4,000. Upon motion, subscription papers were circulated among those present, and an additional $110 was quickly raised in small sums.

Professor Swallow arose to a question of privilege. He had observed by the morning papers and by the remarks of the Fellows of this Association that an unfortunate misapprehension existed as to the animus of the meeting held yesterday by some geologists. It had been supposed this meeting was inspired by a dissatisfaction on the part of the geologists with their position in this Association. He had consulted with many of his associates in that movement, and could speak with authority for them and for himself. They had no idea of withdrawing themselves or their work or their love from this our Association. It would be strange to see the eldest son leave the family home because some younger brother had become as smart, or, it may be, a little more active than himself. We say to the other and younger Sections, God speed you all! We geologists cannot get along without you chemists, you biologists, you physicists, and you entomologists. We need you all. But we had two objects in view:

1. We wished to consult about our position in the American Association for the Advancement of Science, as there is to be a readjustment of Sections. We will determine what we want, and we feel confident that you will grant us all we ask in reason.

2. We wished to consult about forming a Geological Society for purposes which this Association does not propose to accomplish, and which it cannot, in the nature of the case, accomplish.

One of these objects is the formation of a geological library, in which the geologist can find what has been done in all departments of his science. No such library now exists. Now, the publications issue from a hundred sources, and it is well nigh impossible for a private individual to collect all these publications and keep them in working condition. One can scarcely describe a new fossil now for fear some one has already described it. We want a library where all these publications will be collected and arranged, to which one may go or apply for information. But there need be no fears that the geologists will lose their interest in the Association for the Advancement of Science.

The GENERAL SECRETARY read the names of 49 persons recommended to membership by the STANDING COMMITTEE, making 324 in all, so far proposed. They were all duly elected.

The report of the SUBCOMMITTEE appointed by the STANDING COMMITTEE to consider and report upon the subject of conferring the degree of Ph. D. was submitted as follows:

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

TO THE STANDING COMMITTEE OF THE ASSOCIATION: Your Subcommittee have taken into consideration the subject referred to them, and respectfully report the following preamble and resolutions, with the recommendation that they be brought before the Association for its action during the present session:

WHEREAS, Many Colleges in the United States have in recent years conferred the Degree of Doctor of Philosophy, not by examination, but *honoris causa:*

Resolved, 1. That this Association concurs with the AMERICAN PHILOLOGICAL ASSOCIATION in deprecating the removal of this degree from the class to which it belongs (viz.: B. D., LL. B., M. D., and Ph. D., degrees conferred after examination), and its transfer to the class of honorary degrees.

2. That a Committee of six, including the President of the Association, be appointed by the Chair to coöperate with the Committee of the American Philological Association in addressing a memorial to the Boards of Trustees of all Colleges in the United States empowered to confer degrees, stating the objection to conferring the degree of Ph. D. *honoris causa,* and praying them to discontinue the practice, if it exists, in the Colleges under their control.

H. CARRINGTON BOLTON,
C. E. DUTTON,
F. W. CLARKE.

The resolutions having been accepted by the STANDING COMMITTEE, and the degree of Doctor of Science included in the recommendation, the report was submitted to the Association.

A motion was made to adopt the resolutions. In seconding the motion, Prof. F. W. CLARKE urged the attention of the Association to the importance of the question. He said that while formerly it had been necessary to work for the degree, and its worth was unquestionable, it had now become an honorary degree conferred by some colleges without regard to the attainments of the recipient. It had been cheapened and made to mean nothing. He stated that Prof. J. W. WHITE, of Harvard, was present as the representative of the AMERICAN PHILOLOGICAL ASSOCIATION, and that he hoped to hear from him before the final vote was taken on the resolutions.

Professor WHITE, being called for, said:

MR. PRESIDENT, LADIES AND GENTLEMEN:—The gentleman who has just seconded the resolutions recommended for adoption by your Standing Committee has suggested that I should be asked to speak to the general question as the representative of the American Philological Association. I am glad that he has thus explained my presence here. While very proud of this bit of ribbon in my button-hole, I am yet too young a devotee of science to look upon this badge with any vivid sense of the rights of proprietorship. It is rather an honor given me in virtue of my office. And yet I ought to add that your Permanent Secretary, in his own skilful way, has almost convinced me that I am an anthropologist. At this discovery I am naturally much pleased.

I have the honor, then, to present you the resolutions passed by the American Philological Association, at its recent session in Cleveland. The two other members of the Committee, appointed under the second resolution, are Prof. Irving J. Manatt, of Marietta College, and Prof. Charles R. Lanman, of Harvard University. I regret that these gentlemen are not present; but in what I shall have to say I shall express views with which they are entirely in accord, and I hope not to trespass long upon your time in presenting the reasons which led our Association to pass the resolutions which I now transmit to you.

It fills one with melancholy, Mr. President, to see to what a pass we are come in this country with our honorary degrees. There are, doubtless, many reasons on account of which we should congratulate ourselves on the form of government under which we live; and it may be true that the interests of the higher education are better subserved among us, under a democracy, than in what many are pleased to call the effete despotisms of Europe—say Germany, for example, whose educational system is notorious. But the complete lack of state-supervision of the higher education among us, the want of a general plan of control for all the colleges, the utter independence of the individual college, have often led to ill-considered action. This proposition meets its illustration, in a large way, in the existing practice in conferring degrees.

There are, sir, in the United States, it is said, 415 institutions of a collegiate grade. These colleges and universities receive their charters from the legislatures of the states in which they may be situated. These charters give them, among other rights, the unlimited right to confer degrees; and it is a matter of surprise to see how large is the list which our unchecked ingenuity has contrived to devise. The most of us, doubtless, have seen the catalogue of that great producer of new light, Neophogen College, in Tennessee—to whose great discoverer I am happy to pay honor in the person of the gentleman who has just preceded me—with its endless list of degrees; and I myself remember (and the bit of history will be allowed me when I account it my good fortune to have been born in the city of Cincinnati and to have been brought up in the great state of Ohio) that the president of a college not 150 miles from where we are sitting once told me, with a face shining with pride, that his college

gave seventeen different degrees. One of these, I remember, was M. P., which on interpretation meant, not Member of Parliament, but Master of Penmanship.

We all know, ladies and gentlemen, the bad odor into which the degree of D. D. has fallen among us, and that other degree, which means the same thing, of S. T. D., which, if the favor into which it has recently been growing in this country could be investigated, would perhaps prove to be an attempt on the part of the clergymen to escape the odium attaching to the D.D. But a word is, nevertheless, to be said for the colleges. If the trustees of our colleges were permitted to speak they could, doubtless, tell a tale of great pressure brought to bear upon them by ambitious men striving for a degree, either openly or through their friends; nay, of the greatness of the temptation which they themselves feel to confer honorary degrees in order that they may strengthen themselves in the communities where their colleges are situated by honoring some prominent man. But it is not the purpose of the resolutions which I bring you from the American Philological Association to attempt to curtail the rights of the colleges, either in the variety or in number of the degrees which they confer. That, like any attempt now to limit the universal suffrage, would perhaps be unwise, and certainly would be futile.

But there is an evil, Mr. President, which provoked these resolutions, for which there ought to be a remedy. That evil is the removal of the degree of Ph. D. to the class of honorary degrees. And let me add the degree of S. D. It was not through oversight of that degree that our association did not include it in its resolutions, but doubtless through ignorance of the fact, which has just been stated, that it also, though so recent a degree, has been given *honoris causa*.

That the fact, sir, stated in our preamble, is true, there can be no doubt whatever. The degree of Ph. D. has been conferred *honoris causa*, I am credibly informed, many times in this state. The most prominent university in the west gave it so last commencement. It has been conferred as an honorary degree in the states of New York and Pennsylvania; and at their recent commencements last June two famous colleges in New England gave the degree without examination, the one once and the other five times. This list might, unfortunately, be greatly enlarged.

Yet there should be little doubt in any one's mind that this degree should be awarded only after examination, belonging as it undoubtedly does to the class of second or graduate degrees—all strictly professional degrees—which includes the B. D., the LL. B., and the M. D. Among the Germans, from whom we get it, it is unquestionably a parallel degree to the other three, and like them is awarded after examination. There was a time at the Universities of Paris and Bologna when the teachers were called *masters*. This was when there was the one faculty of the seven liberal arts. But with the rise in the 13th century of the three later faculties of law, theology and physic, the teachers in these gradually came to be called exclusively *doctors*. The term master, which was

then applied to the teachers of arts alone, became in course of time colorless, just as now it has suffered universal decadence. And it was to rescue the masters of the liberal arts, which term they now comprehend in the one word "philosophy," that the Germans seem to have established the degree of doctor of philosophy. When a young man there enters the university from the gymnasium on the certificate of a successful *abiturienten-examen*, he pursued studies that will make him in three years either a licentiate in divinity, a doctor of laws, or a doctor of philosophy, or in four years a doctor of medicine. The majority study "philosophy," which, as already said, is a comprehensive term including (1) philosophy proper; (2) philology; (3) history, political economy and finance, and (4) mathematics and the physical sciences. Now, those of our own universities which offer graduate courses of study, such as Harvard and Yale, the Universities of Cincinnati and Michigan, and some others, make the degree exactly what it is among the Germans. It means that the candidate has been in residence for a given period of years, has pursued a course of liberal studies under direction, has presented a thesis, and passed an examination. If their practice becomes general, we shall have a doctorate which will signify as certainly that a man has made especial and advanced studies in philosophy, *i. e.*, in the liberal arts, as the M. D. signifies special studies in medicine, and we shall thus establish a degree which will be in a preëminent sense the teachers' degree; whereas, if we give it *honoris causa*, we shall cheapen it, and eventually make it worthless. If this degree belongs historically with the other three, if the universal practice in Germany and the best practice in our own country put it there, the burden of proof of the propriety of its alienation to the class of honorary degrees may well be made to rest upon those who would advocate doing this. With what greater propriety can the degree of Ph. D. be given *honoris causa* than the degree of M. D.? We can hardly be said to have come to that. An attempt, nevertheless, was recently made in Philadelphia, but under another form, to confer the M. D. upon persons who had not studied medicine. The sequel was entirely satisfactory. The philanthropist who conceived that brilliant idea now carries on his philosophical speculations behind the bars of a prison.

The argument in favor of the practice which we would discourage may perhaps be made in this form: That the opportunities for advanced study in philosophy are not great in this country, and were formerly less than they are now; that there is many a man who was unable to avail himself of these opportunities when he was younger, and cannot do so now because he is actively engaged; that he has, nevertheless, proved himself to be worthy of the degree; that it is only fair, therefore, that he should be honored with it now without examination. The answer to this argument, briefly stated, would be: First, that remembering how great the number of colleges in the country is which are empowered to confer degrees, it is certain that, if the restriction of an examination should once be removed, the degree would oftener be conferred upon a low and improper stand-

ard than worthily; and secondly, that to refuse this exceptional man the degree upon the condition of no examination is in reality no hardship, since if he is really the scholar which it is claimed that he is, there remains for him either immediately or within a few years the L L. D., a degree which once at least had an honorable literary significance among us, and might still be rescued from the dangerous position into which, as the seconder of the resolutions has pointed out, it has fallen.

If now it is agreed, sir, that the practice of which I have been speaking should be discouraged, by whom should the statement of the objections to it and the request that it be discontinued be made? It seemed to a majority of the members of the American Philological Association that this should be done by the two associations named in the resolutions. We are the persons mainly affected. The degree for which the members of these associations who have taken a higher degree have been examined is not the B. D., the LL. B., nor the M. D., but the Ph. D., or the S. D. A memorial, therefore, such as the resolutions suggest, would properly come from us. If, on the ground that these are learned bodies, whose function is to discuss problems of science and philology, we decline to take steps to remedy what we believe to be an evil, who will move in our behalf? It is surely in no sense improper or undignified for these two associations to address Boards of Trustees on a question of such vital importance, and such an address would probably be effectual. There is reason to believe that the degree of Ph. D. is now conferred *honoris causa* in the majority of cases through ignorance or oversight of its real meaning and value. A memorial which should state clearly its historical significance, its present honored place among the degrees conferred in German Universities, and its immense value to us in furthering the higher education, if it should be made to mean everywhere and always advanced study under direction *and an examination*, would, even if it did not entirely do away with the practice which we deprecate, turn the tide and save to us a degree which we can ill afford to lose.

So I present to you, ladies and gentlemen, the request of the American Philological Association that you will, through a committee to be appointed with powers, join them in addressing such a memorial to the Boards of Trustees of all colleges in the United States. That association, sir, recognizes the precedence of the American Association for the Advancement of Science as the older, the larger, and the more influential body, and would be unwilling to take steps alone. The decision, therefore, of the important question, whether such steps shall or shall not be taken, rests with you.

A vote was then taken on the motion, and the resolutions were unanimously adopted, and the following committee appointed in accordance therewith:

GEO. J. BRUSH, of New Haven, *chairman*, WM. B. ROGERS, of Boston, F. A. P. BARNARD, of New York, H. C. BOLTON, of Hartford, J. P. LESLIE, of Philadelphia, F. W. CLARKE, of Cincinnati.

The following letters were referred to the NOMINATING COMMITTEE.

TO THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE:

I have the pleasure of conveying to the American Association for the Advancement of Science the cordial invitation of the Minnesota Academy of Natural Science, to meet in Minneapolis.

The City of Minneapolis, through its Mayor, Board of Trade, Common Council, School Directors and other corporations, has seconded the invitation of the Minnesota Academy. The Governor of the State of Minnesota and the President of the University of Minnesota, in behalf of the Faculty and Regents, communicate their promised coöperation, and several other individuals and educational institutions heartily unite in the invitation.

For the Academy,

N. H. WINCHELL, President.

MINNEAPOLIS, May 28, 1881.

MY DEAR SIR: I am in receipt of yours of the 25th inst., with reference to holding the Convention of the American Association for the Advancement of Science in our city in 1882.

I need not say that it would afford me, in common with all citizens of this city, the greatest pleasure to have such Convention held here, and I have no doubt Minneapolis, true to her traditions in affording all facilities and accommodations for such meetings, will do her duty in this case. I think you can safely say to those who have the selection of the point of holding the Convention in charge that Minneapolis will do its whole duty.

Hoping you may succeed in bringing the Convention here, I remain, yours very truly,

Dr. P. L. Hatch, city. W. D. WASHBURN.

MAYOR'S OFFICE, MINNEAPOLIS, MINN., June 6, 1881.

TO THE PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE:

MY DEAR SIR: The City of Minneapolis invites you to hold your annual meeting here. We do not mean this in the conventional sense, but cordially and earnestly tender the invitation, and trust you may honor us by accepting it.

Very respectfully,

A. C. RAND, Mayor.

MINNEAPOLIS, June 7, 1881.

PROF. N. H. WINCHELL, President Minnesota Academy of Science:

DEAR SIR: Will you have the kindness to extend to the American Association for the Advancement of Science the invitation of the Regents and Faculty of this institution to hold their annual meeting (1882) in Minneapolis? You may assure the Association that any rooms, books or apparatus possessed by the University will be cheerfully placed at its disposal. Very truly and respectfully yours, etc.,

WILLIAM W. FOLWELL, President.

TORONTO, August 16, 1881.

MY DEAR SIR: I beg to inform you that the Senate of the University of Toronto at its last meeting resolved to extend a cordial invitation to the American Association for the Advancement of Science to hold their next meeting at Toronto, and will deem it an honor to assist in making that meeting in every way successful. I enclose a letter from the Acting Minister of Education for Ontario, from which you will see that the Government will give you a hearty welcome.

Will you please lay this invitation before the proper Committee, for their favorable consideration, and convey to them the assurance that your association will meet with hearty welcome from the members of kindred institutions here and from our citizens at large?

I regret that I am not able on account of illness to be present at Cincinnati to present the invitation in person.

Yours faithfully,

To the Permanent Secretary, A. A. A. S. J. LOUDON.

A letter was also read from President DAVIDSON, of the California Academy of Science, inviting the Association to meet at San Francisco in 1883.

The LOCAL SECRETARY announced that the excursion to Madisonville had been arranged for Monday afternoon, and those members of the Association who desired to avail themselves of this opportunity to visit the objects of anthropological interest in that locality were requested to report to him or to the Permanent Secretary. The General Session then adjourned.

Saturday, August 20, 1881.—President BRUSH called the Association to order at 10.30.

The GENERAL SECRETARY announced the action of the STANDING COMMITTEE in regard to honorary fellowship, stating that Prof. WILLIAM B. ROGERS of Boston, Mass., had been unanimously proposed as the first Honorary Fellow of the Association. The action of the Standing Committee had been unanimously indorsed by the Sections A and B, and with much enthusiasm Professor ROGERS was elected without a dissenting vote.

Prof. T. C. MENDENHALL, by authority of the STANDING COMMITTEE, spoke in favor and in praise of the Seismological Society of Japan. He showed that Japan furnished exceptionally favorable opportunities for studying earthquakes and all their bearings, and made an earnest appeal for contributions toward a fund for furthering the work of the society, and urging members to join it, the conditions of membership being the payment of $5.00.

The CHAIR announced the action of the NOMINATING COMMITTEE in favor of Montreal as the next annual meeting place of the Association. This announcement was received with great applause. Before the motion con-

firming the action of the NOMINATING COMMITTEE was put to the meeting, Judge J. G. HENDERSON, of Winchester, Ill., offered an amendment to the effect that the name of Minneapolis be substituted in place of Montreal. The amendment was lost, whereupon Montreal was, by almost an unanimous vote, selected as the next place of meeting. Judge HENDERSON rose a second time and announced that he had been authorized by the citizens of Minneapolis to state that, since the next convention of the Association would not be at that city, they respectfully asked the action of the meeting to have the convention of 1883 in their midst. He therefore moved that Minneapolis be recommended to the NOMINATING COMMITTEE as the place of meeting for 1883. In supporting his motion, Judge HENDERSON gave a glowing description of the progress made in Minneapolis since the last meeting of the Association in the northwest. The motion was carried.

The PERMANENT SECRETARY announced that he had just received notice of the death of Col. C. G. FORSHEY, of New Orleans, an old member of the Association.

He also read the following dispatch from General Hazen.

WASHINGTON, D. C., Aug. 19, 1881.

HON. A. T. GOSHORN:

I regret that my duties here will prevent my meeting the American Association for the Advancement of Science.

W. B. HAZEN.

By request of the inventor, GEO. H. KNIGHT, the announcement was made that there would be an exhibition of an electric lamp for the benefit of members of the A. A. A. S., at 2 P. M., at Ruthven's Foundry, No. 222 West 2d street. Such members as desired to inspect the improvement were cordially invited.

The GENERAL SECRETARY announced the list of Fellows which the STANDING COMMITTEE recommended for election, and, on motion, it was ordered printed for consideration on Monday.

The GENERAL SECRETARY then read at length the articles in the Constitution with the amendments proposed at the last general meeting in Boston and as recommended by the STANDING COMMITTEE. The amendments were unanimously adopted. [The amendments are incorporated in the Constitution as printed in the first part of this volume.]

He then read a list of 38 persons whom the STANDING COMMITTEE recommended to membership, making 362 in all, and they were unanimously elected.

Monday, August 22, 1881.—The Association convened in Power Hall, and President BRUSH called it to order at 10.30 A. M.

Upon announcement by the CHAIR that the STANDING COMMITTEE rec-

ommended that the Montreal meeting begin on the fourth Wednesday in August, the recommendation was endorsed by an unanimous vote.

The PERMANENT SECRETARY read the following dispatch:

NEWPORT, R. I., Aug. 21, 1881.

PROF. F. W. PUTNAM, Permanent Sec'y,
A. A. A. S., Music Hall.

Warmest thanks for this great honor and the kind appreciation it speaks. Wish I were with you to show how much I enjoy the success of this great Cincinnati meeting.

WILLIAM B. ROGERS.

The NOMINATING COMMITTEE submitted a report nominating the officers for the ensuing year, and the following were unanimously elected:

President, J. W. DAWSON, of Montreal.

General Secretary, WM. SAUNDERS, of London, Ontario.

Assistant General Secretary, J. R. EASTMAN, of Washington.

Treasurer, WM. S. VAUX, of Philadelphia.

Section A, Mathematics and Astronomy: WILLIAM HARKNESS, of Washington, Vice President; H. T. EDDY, of Cincinnati, Secretary.

Section B, Physics: T. C. MENDENHALL, of Columbus, Ohio, Vice President; CHARLES S. HASTINGS, of Baltimore, Secretary.

Section C, Chemistry, including its Application to the Arts: H. CARRINGTON BOLTON, of Hartford, Vice President; ALFRED SPRINGER, of Cincinnati, Secretary.

Section D, Mechanical Science: WILLIAM P. TROWBRIDGE, of New Haven, Vice President; CHARLES B. DUDLEY, of Altoona, Penn., Secretary.

Section E, Geology and Geography: E. T. COX, of San Francisco, Vice President; C. E. DUTTON, of Washington, Secretary.

Section F, Biology: W. H. DALL, of Washington, Vice President; CHAS. S. MINOT, of Boston, Secretary.

Section G, Histology and Microscopy: A. H. TUTTLE, of Columbus, Vice President; ROBERT BROWN, jr., of Cincinnati, Secretary.

Section H, Anthropology: DANIEL WILSON, of Toronto, Vice President; OTIS T. MASON, of Washington, Secretary.

Section I, Economic Science and Statistics: E. B. ELLIOTT, of Washington, Vice President; FRANKLIN B. HOUGH, of Lowville, N. Y., Secretary.

The PRESIDENT announced that the term of office of the present PERMANENT SECRETARY continued for the next three meetings. This announcement was received with great enthusiasm, for which the Permanent Secretary bowed his acknowledgments.

The CHAIR then announced that the printed list of members whom the STANDING COMMITTEE recommended for Fellows would be distributed,

and he appointed Messrs. PETTEE, STOCKWELL, PECKHAM and MASON to act as tellers.

The total number of ballots cast was 106, and as none of the names were scratched on more than four tickets, they were all declared elected, as follows:

Ammen, Rear Admiral Daniel, U. S. Navy, Beltsville, Md. (26).
Atkinson, Edward, 131 Devonshire St., Boston, Mass. (29).
Ballou, George F., Waltham, Mass. (29).
Belknap, George E., Captain U. S. N., Malden, Mass. (29).
Bowser, Prof. E. A., Rutgers College, New Brunswick, N. J. (28).
Buckhout, W. A., State College, Centre Co., Pa. (20).
Carhart, Prof. Henry S., Evanston, Ill. (29).
Cox, Hon. J. D., Cincinnati, Ohio (30).
Coxe, Eckley B., Drifton, Jeddo P. O., Luzerne Co., Pa. (23).
Crosby, Wm. O., Mass. Inst. Technology, Boston, Mass. (29).
Davidson, Prof. Geo., Ass't Coast and Geodetic Survey, San Francisco, Cal. (29).
Draper, Daniel, Ph. D., Director N. Y. Meteorological Observatory, Central Park, 64th St., Fifth Avenue, New York, N. Y. (29).
Drown, Prof. Thos. M., Lafayette College, Easton, Pa. (29).
Dudley, Wm. L., Miami Med. College, Cincinnati, Ohio (28).
Edwards, Henry, Wallack's Theatre, New York, N. Y. (28).
Ferguson, Maj. Thos. B., Ass't U. S. Fish Commissioner, Washington, D. C. (28).
Fernald, Prof. Charles H., State Agricultural College, Orono, Me. (22).
Fletcher, Dr. Robert, Surgeon General's Office, Washington, D. C. (29).
Gage, Simon Henry, Ithaca, N. Y. (28).
Gallaudet, Edward M., Pres. Nat. Deaf Mute College, Washington (28).
Hall, Edwin H., Johns Hopkins University, Baltimore, Md. (29).
Hayden, Dr. F. V., 1910 Arch St., Philadelphia, Pa. (29).
Hill, Franklin C., P. O. Box 338, Princeton, N. J. (29).
Hill, Prof. Walter N., U. S. Torpedo Station, Newport, R. I. (29).
Hitchcock, Romyn, 53 Maiden Lane, New York, N. Y. (29).
Hoffmann, Dr. Fred., 797 Sixth Avenue, New York, N. Y. (28).
Holmes, Dr. Oliver Wendell, 296 Beacon St., Boston, Mass. (29).
Hyde, Prof. E. W., Walnut Hills, Cincinnati, Ohio (25).
Jeffries, B. Joy, M. D., 15 Chestnut St., Boston, Mass. (29).
Jillson, Dr. B. C., Pittsburgh, Pa. (14).
Johnson, Prof. W. W., Annapolis, Md. (29).
Kedzie, Prof. Robert C., Lansing, Mich. (29).
Kent, William, Pittsburgh, Pa. (26).
LeConte, Prof. Joseph, University of California, Berkley, Cal. (29).
Ledoux, Albert R., Ph. D., 17 Cedar St., New York, N. Y. (26).
Lord, Prof. Nat. W., State University, Columbus, Ohio (29).
Loudon, Prof. James, Toronto, Can. (25).
Lyman, Benj. Smith, Northampton, Mass. (15).

Lyons, T. A., Lieut. U. S. N., U. S. Flagship Trenton (28).
Mabery, C. F., Cambridge, Mass. (29).
Markoe, Geo. F. H., 61 Warren St., Roxbury, Mass. (29).
McCauley, Capt. C. A. H., U. S. A., Reading, Pa. (29).
Mew, Wm. M., Army Medical Museum, Washington, D. C. (29).
Miller, S. A., Cincinnati, Ohio (26).
Murtfeldt, Miss Mary E., Kirkwood, Mo. (27).
Nichols, E. L., Ph. D., Johns Hopkins University, Baltimore, Md. (28).
Norwood, Charles J., Ass't Ky. Geological Survey, Russellville, Ky. (26).
Osler, Prof. William, McGill College, Montreal, Canada. (28).
Parke, John G., Lt. Col. Corps of Engineers, Bv't Maj. Gen. U. S. A., Office of Chief of Engineers, Washington, D. C. (29).
Peet, Rev. Stephen D., Clinton, Wis. (24).
Peirce, Prof. James M., Cambridge, Mass. (28).
Peter, Dr. Robert, Ky. Geol. Survey, Lexington, Ky. (29).
Pike, Dr. W. H., University College, Toronto, Can. (29).
Pritchett, Henry S., Morrison Observatory, Glasgow, Mo. (29).
Procter, John R., Director Ky. Geol. Survey, Frankfort, Ky. (26).
Rice, John M., U. S. Naval Academy, Annapolis, Md. (29).
Sampson, Com'd W. T., U. S. N., Naval Academy, Annapolis, Md. (25).
Short, Sidney H., Ohio State University, Columbus, Ohio (28).
Smith, Quintius C., M. D., P. O. Box 6, Austin, Texas (26).
Snow, Prof. F. H., Lawrence, Kan. (29).
Story, Wm. E., Johns Hopkins University, Baltimore, Md. (29).
Sutton, Dr. George, Aurora, Dearborn Co., Ind. (20).
Tainter, Sumner, Watertown, Mass. (29).
Taylor, Wm. B., Smithsonian Institution, Washington, D. C. (29).
Todd, D. P., Nautical Almanac Office, Washington, D. C. (27)
Townshend, Prof. N. S., Columbus, Ohio (17).
Tracy, Sam'l M., Columbia, Boone Co., Mo. (27).
Warder, Prof Robert B., North Bend, Hamilton Co., Ohio (19).
Woerd, Chas. V., American Watch Co., Waltham, Mass. (29)
Wood, Prof. De Volson, Hoboken, N. J. (29).
Woodward, J. J., M. D., Army Medical Museum, Washington, D. C. (28).

The General Secretary read a list of ten persons recommended to membership, making in all 372, and they were unanimously elected.

The General Secretary then read the following telegram from the newly elected President, who had been informed by telegraph of his nomination and the probability of his election:

Little Metis, Ont., August 20, 1881.

Prof. F. W. Putnam:

The Association will have cordial welcome to Montreal, and may command my services in any capacity.

J. W. Dawson.

The PRESIDENT then announced that the Special Committees, which, according to the Constitution, should have reported to the Standing Committee, had failed to do so, but that if any members of the Committees were present and desired to report progress, they would now have the opportunity.

Mr. G. W. HOLLEY, of Niagara Falls, on behalf of the Committee to MEMORIALIZE THE LEGISLATURE OF NEW YORK FOR A NEW SURVEY OF NIAGARA FALLS, reported progress. He thought that inasmuch as the changes in the falls necessitated a new survey, and as the present Committee, separated as they were by distance, and rarely seeing each other, could not hope to secure the desired legislation by the New York State Legislature, the Committee should be dismissed and a new one appointed.

The following resolution from the STANDING COMMITTEE was offered and adopted:

Resolved, That the Committee, now in charge of the duty of petitioning the Legislature of the State of New York for a new survey of Niagara Falls be discharged, and a new one, consisting of Messrs G. W. HOLLEY, of Niagara, and J. T. GARDNER, of Albany, N. Y., be appointed.

The Committee on PERMANENT FUNDS was continued.

Dr. J. LAWRENCE SMITH, in the absence of the Chairman, reported the PERMANENT COMMITTEE of WEIGHTS and MEASURES wide awake, and taking every opportunity to aid in accomplishing its important task. He hoped by the next meeting it would be able to make a report of definite progress.

The Committee ON STELLAR MAGNITUDES, through Professor HARKNESS, reported progress. The report of the Committee was being printed,[1] and would soon be published and placed in the hands of every member, but as it was of a somewhat technical character, and of little interest except to astronomers he begged to make merely a verbal report. No objection being made he did so, and the Committee was continued.

Professor E. B. ELLIOT, of the Committee ON REGISTRATION OF BIRTHS, DEATHS AND MARRIAGES, reported as follows.

There is reason for the conviction that at the next session of the Congress of the United States (the forty-seventh) there will be action relative to the events of birth, death and marriage, by authorizing a coöperation between the general Government of the United States and of the several States to this end The subject is not considered by members of Congress of either branch in the light of partisan legislation, and the measure proposed is favored by prominent and leading men of the House of Representatives of both political parties. The importance to the community of instituting an exhaustive report of these events as they occur need not now be dwelt upon. It is estimated that hereditary property changes hands once in every twenty or twenty-five years: the relative salubrity of localities, with its changes from time to time, is a subject

[1] The Report is given on page 1 of this volume.

upon which the public need information, and facilities for the construction of life tables and of monetary tables in which the mean probable future duration of human life in our own country is involved, is a subject of prime importance. Our tables of life annuities, etc., are all compiled in other countries, and based upon the experience of population on other than American soil. The American Public Health Association and the American Meteorological Association coöperate with this Association; and other Associations will doubtless add the weight of their influence. The members of the Committee present at this meeting respectfully ask its continuance.

The report was accepted and the Committee continued.

The Committee ON THE BEST METHODS OF SCIENCE TEACHING IN THE PUBLIC SCHOOLS was continued.

The Committee ON STANDARD TIME submitted a majority and minority report. Prof. ORMOND STONE read the majority report of the Committee present, and Prof. LEONARD WALDO, the minority report.

The Committee was continued and the reports were accepted for publication in the Cincinnati volume. [See p. 4.] The Standing Committee were requested to designate a special time for the consideration of the reports at the Montreal meeting next year.

A resolution was passed to the effect that a representative Canadian be appointed by the committee to be one of their number.

The GENERAL SECRETARY announced that the STANDING COMMITTEE has recommended the following persons as a Committee ON STATE GEOLOGICAL SURVEYS for the purpose of considering the modes of securing the best Scientific and Economic results: G. C. SWALLOW, Mo., JAS. HALL, N. Y., J. R. PROCTER, Ky., N. H. WINCHELL, Minn., W. C. KERR, N. C., J. W. POWELL, Washington, EDWARD ORTON, Ohio.

The action of the Committee was approved.

Tuesday, August 23, 1881.—The Association met at 10.30, A. M., in Power Hall, President BRUSH in the chair.

The GENERAL SECRETARY submitted the following from the STANDING COMMITTEE:

WHEREAS, The Earl of Dufferin, late Governor General of Canada, the duties and comities of which position he discharged and practised with such eminent ability and success, recommended, before the close of his official term, that measures should be adopted to secure the establishment of an International Park, the central point and attraction of which should be the Falls of Niagara; and

WHEREAS, The Dominion Parliament subsequently appointed a commission to consider the subject, which commission, it is understood, will report favorably thereon; and

WHEREAS, The Legislature of the State of New York also appointed a similar commission, which has already reported in favor thereof; therefore,

Resolved, That the members of this Association do cordially and earn-

estly declare their approval of this project and their hope that it may be accomplished, and that in consideration of the international importance of this question we earnestly pray the Congress of the United States to secure by national laws the establishment of this park upon such territory as falls within its jurisdiction; and

Resolved, That the members of this Association hereby constitute themselves a committee of the whole to aid in securing the success of this recommendation.

Mr. G. W. HOLLY, of Niagara, on behalf of the resolution, addressed the meeting in reference to the falls. He regretted that there was now not one inch of ground at the falls from which the mighty cataract might be viewed without charge. He could not object to property holders doing with their own as they pleased, and yet some means ought to be taken to do away with the small barter practised there.

Prof. WM. H. BREWER, of New Haven, called attention to the difficulty of doing away with the peddling business at Niagara Falls. Property holders had paid a great price for their possessions there with a view of realizing handsome profits. Still he was in favor of the motion as read.

General J. D. Cox said that he took great pleasure in seconding the resolutions. He did not believe that the task of redeeming Niagara Falls for the people was hopeless. We, in common with all the world, feel that it is belittling to us as a people to have the sights of that magnificent and august spectacle peddled out, and he could only add his hearty approval of the proposed plan, and sincerely hoped that it would prove successful.

The resolutions were then unanimously adopted.

A communication was read from F. BARON DE THUEMEN, of the Imperial Royal Station of Essays, Vienna, Austria, in which he states that he has undertaken a bibliographic work about all newspapers, journals, and society papers, treating of botany.

Twenty-three new members were elected and the GENERAL SECRETARY announced that the total number of new members elected at the meeting was 395, a larger number by far than at any previous meeting except that at Boston in 1880. Adjourned to meet in sections.

Tuesday, August 23, 1881. Evening Session.—The Association convened again in Power Hall at 8.20, P. M. President BRUSH in the chair.

The CHAIR announced that the STANDING COMMITTEE had invited Mr. THOMAS MEEHAN to deliver a lecture before the Biological Section at the Montreal Meeting.

Prof. STONE, on behalf of the Local Committee, announced that the excursion to Mammoth Cave would leave the Little Miami depot at 7 A. M. on Wednesday, and the one to Chattanooga and Lookout Mountain would leave the Southern Railroad depot at the same time.

Nine additional members were elected, making a total of 404.

The following resolutions were then offered and adopted:

Resolved, That we offer our thanks to the Local Committees of Cincinnati for the admirable skill and system with which they have arranged every detail of plan for the accommodation of the Association; for their prompt and business-like executive work; indefatigable attention to both general and special objects, by which attention the meeting of 1881 has been the most successful ever held in the West, and the largest and most interesting ever held in America except the phenomenal meeting at Boston.

Seconded by Rev. Dr. J. G. MORRIS.

Resolved, That the hearty thanks of this Association be tendered to the citizens of Cincinnati for their bounteous hospitality, which they, through their Committees, have extended to this body; provided for the yearnings of our human nature; for the brilliant reception and entertainment at the Highland House; for the genial supper at the Zoölogical Garden; and for those daily lunches at the Hall which have contributed so much to our peace and comfort.

Seconded by Prof. WM. H. BREWER.

Resolved, That the members of the Association are greatly indebted to the Commissioners of the Cincinnati Industrial Exposition for the use of their spacious quarters and for opening the Exhibition of scientific specimens and apparatus in advance, out of courtesy to this Association; and to the Ohio Mechanics Institute for the organization and arrangement of this most valuable and instructive Exhibition.

Seconded by Prof. H. CARMICHAEL.

Resolved, That we thank the Cincinnati Southern and the Cincinnati and Louisville Railroads for the great pleasure which is still in store for members of this Association in the invitations which they have tendered the Association, to visit Chattanooga and the Mammoth Cave. These invitations are accepted with a just appreciation of the magnitude of the courtesy extended.

Seconded by Dr. A. B. HERVEY and Prof. O. T. MASON.

Resolved, That the thanks of the Association are due to the Railroad and Express Companies whose lines enter Cincinnati, for the liberal concessions which they have made to members of the Association, to which the large attendance and success of the present Meeting have in a great measure been due.

Seconded by Judge J. G. HENDERSON.

Resolved, That the thanks of the Association are hereby most cordially tendered to the managers and proprietors of the Zoölogical Garden for excursions to their beautiful garden, the sight of their splendid animals, and the most pleasurable entertainment.

Seconded by Prof. G. C. SWALLOW.

Resolved, That the thanks of the Association be tendered to the members of the Literary and Scientific Society of Madisonville for their kindness in arranging for the visit to the very interesting and ancient burial-place at Madisonville, and for the cordial reception given to the large party accepting the invitation on Monday last.

And also be it *Resolved*, that this Association most heartily endorses the careful methods with which the explorations of the ancient cemetery have been conducted.

Seconded by Prof. F. W. PUTNAM.

Resolved, That the thanks of the Association are due to the newspapers of Cincinnati for their full and accurate reports of each day's session, and for the courteous interest in the aims and labors of the Association which they have shown in their editorial columns.

Seconded by Prof. E. T. COX.

Resolved, That the thanks of the Association are due to the Western Union Telegraph Company and to the City and Suburban Telephone Association of Cincinnati, for their generous donation of the free use of their lines to the members of the Association during the meeting, by means of which the transaction of the business of the meeting has been greatly facilitated, and the comfort of the visiting members greatly enhanced.

Seconded by Prof. E. B. ELLIOTT.

Resolved, That the thanks of the Association are due to Mrs. Maria Nichols for her kindness in inviting members of the Association to visit Rookwood Pottery; to the First Presbyterian Church for the use of their building on the occasion of evening lectures delivered before the Association; and the University Club, Cuvier Club, Cincinnati Society of Natural History, Young Men's Mercantile Library Association, Young Men's Christian Association, Cincinnati Gymnasium, and the Merchants' Exchange, for the hospitalities which they have extended to the members of the Association.

Seconded by Prof. E. S. MORSE.

Gov. J. D. COX then addressed the Association in the following words:

I rise, Mr. President, to propose a sentiment which I fear may seem too strongly in contrast with the humorous and jocose vein which has naturally characterized most of the remarks at this evening meeting. But I have found my own feeling shared by so many others that I have been encouraged to mention a subject which I know has been much in the hearts and minds of the members of the Association during the session. I refer to the situation of the President of the United States. Day by day since we met we have followed the dispatches telling of his suffering and danger, depressed by threatening symptoms and cheered by

every hopeful turn in his case. Ought we not to record our feeling in the minutes of the Association, to remind us in the future of our sympathy and our anxious suspense, and so complete our recollection of the experiences of this work, both grave and gay?

A scientific association. should, I think, feel more than a common interest in President GARFIELD. All who have had former acquaintance with him know that a love for science was his earliest and strongest intellectual passion, and that during a quarter of a century of important and laborious public service, it has been among his chief delights to renew the studies of his youth, and to seek the society of those who have been devoted to their pursuit.

The earliest public address I ever heard him deliver, before he was engaged in any public office, was upon one of the branches of geology. In his grasp of the subject and in broad generalizations of fact and of theory, he showed the same strong and comprehensive mind which has always marked his career. That he would have been eminent in science as he has since been in statesmanship it is impossible to doubt.

In the turmoil of the era through which we have just passed, the country needed his services in other fields than those of science, and in obedience to the plain call of duty he threw his whole soul into his public work. But whether in the army or in the national legislature, I know that he often sighed for the delights of a studious and learned life; and though he has succeeded in keeping abreast with the progress of knowledge in a way that has astonished us all, he has constantly chafed at his inability to do more. Had he been in vigorous health we may be sure his sympathies would have been with the Association in this meeting, and we should have had some fraternal message from his pen.

By a strange Providence, what seemed the culmination of personal glory and earthly honor has proven only the threshold of a chamber of sufferings and of pains more appalling and protracted than human nature is often called to endure. Whether he shall fall a victim to the horrible crime committed against him and against humanity is perhaps as doubtful to-night as it was when we met a week ago. Each day it has seemed that the extent of his endurance and the limit of his heroic courage had been reached, and yet the crisis has prolonged itself till we hardly know whether fear or hope is in the ascendant.

Were he strong enough to hear a message from this Association, I am sure it would be a comfort to him to know that his own deep interest in science has made your sympathy more tender and earnest, and that your feeling is something more than that of the public at large, deep and strong as the public feeling is.

The hour when we separate is one when the thoughts will naturally take a serious hue, and it has therefore seemed to me that as a closing act in the session, it would be in accordance with all our feelings to unite in passing the following resolution:

Resolved, That we cannot close our annual session without expressing the sorrow and sympathy with which we have followed, from day to day, the sufferings of the President of the United States and the joy with which we have hailed the renewed hope of his recovery. His life-long interest in all learning adds a sentiment of brotherhood in science to the tender interest in him which we feel in common with our fellow citizens. It has increased our anxious solicitude when his condition was most discouraging, and has given great heartiness and depth to our thankfulness when the burden of our fear has been lightened.

The resolution was unanimously adopted by a rising vote, whereupon the PRESIDENT said:

Now, fellow members of the Association, it is my duty to adjourn this body. I wish you all a pleasant excursion and a safe return to your homes, after this delightful meeting at Cincinnati.

CHARLES V. RILEY,
General Secretary.

REPORT OF THE PERMANENT SECRETARY.

THE first western meeting of the Association was at Cincinnati in May, 1851, and a comparison of the record of that meeting, given in the fifth volume of the Proceedings, printed by the liberality of the citizens of Cincinnati, with that contained in the present volume, will show the immense advance which the Association has made during the thirty years that have elapsed since the first meeting was held in the "Queen city of the West." Then there were 87 members present, and 87 papers were read in the general sessions during the five days of the meeting. At the last meeting 182 papers were presented before the six sections and subsections, and over 500 names were entered on the register, while about 400 new members were elected.

Thirty years ago Bache, Henry, Agassiz and Foster offered their testimony to the high position Cincinnati had reached by her encouragement of education, and acknowledged the attainments of her citizens in science and art; and they thanked the citizens of Cincinnati for the hospitality extended to the members of the Association "taking it as an evidence of their interest in the progress of Science." In 1881, another generation of scientists gathered from many places,—from the Atlantic to the Pacific—gave their testimony not only to the continued prosperity and extraordinary growth of the city, but to the noble development of many institutions of learning and culture, which, thirty years ago, called forth words of praise from the early members of the Association; while the cordial greeting and open-hearted hospitality extended by the citizens to the several hundred members during the recent meeting showed that these traits of character had been true to the law of heredity.

The thirtieth meeting of the Association was one of unusual importance. The changes in the Constitution, proposed at the Boston meeting, were agreed to, and as a consequence the next meeting will be held with

an entirely reorganized system of sections, extending the scope of the Association in accordance with the demands which the advance of science has made in various directions. This new organization will also cause nine important addresses to be prepared each year, which, added to the annual presidential address, will naturally result in increasing the interest in the Association, as these addresses will usually be of general interest and not often, probably, of the technical character essential to a large proportion of the papers read at the meetings.

In relation to this change in the sections, which can be best understood by reference to the Constitution printed in the present volume, it is only of importance here to call attention to the fact that each of the nine sections will be presided over by a vice president, and will have its own officers and sectional committee, who will be responsible for the character of its meetings. All the former subsections are given up, but provision is made for the temporary division of a section should the necessity arise. The Standing Committee is increased in size, but not unproportionally, when the extended scope of the Association and the large increase in members are considered.

Another matter of importance, which has been considered at several late meetings, was finally determined by the Standing Committee at the Cincinnati meeting voting that, beginning with the Montreal meeting, every paper read before a section should be entitled to appear by abstract in the volume of Proceedings, unless it was particularly requested by the proper Sectional Committee that it appear by title, and that only in exceptional cases, at the request of a Section, should papers be printed in full. It was thought by the Committee that this plan of publication would add greatly to the value and general interest of the printed proceedings.

The general distress which prevailed throughout the country, owing to the critical condition of President Garfield, unquestionably had its effect on the meeting of the Association, and prevented many members, particularly those holding official positions in Washington, from being present, and the thoughts of members at the meeting were often turned from science to the contemplation of the sufferings of the President and the possible political complications that might arise.

By a sad and unfortunate coincidence the addresses which are usually given by the retiring president and the two vice presidents were not delivered. Mr. Morgan, who was in feeble health at the Boston Meeting, slowly declined during the following year and was unable to prepare the presidential address which he hoped to do even after he realized that he would be unable to go to the meeting. The sad note from him, which was read at the opening session on Wednesday morning, proved indeed his parting message to the Association.

Vice President elect, Dr. Geo. Engelmann, had early sent in his resignation, as he expected to be in Europe at the time of the meeting, but he was prevented by the state of his health from taking the voyage. The other Vice President elect, Prof. A. M. Mayer, was also detained at home by ill health. The vacancies in the offices of Vice Presidents were satisfactorily filled by election at the first session on Wednesday, but the new officers could not give formal addresses. The evening which otherwise would have been occupied by the Presidential address was filled by Capt. Dutton who delivered an instructive and highly interesting lecture on the Cañons of the Colorado, which was illustrated by beautiful lantern pictures taken from photographs. Another evening was assigned to Dr.

Bolton who gave an interesting lecture on the beginnings of the science of Chemistry, and was also illustrated by many lantern pictures.

It is with much satisfaction that I am able to record the success which has thus far attended the efforts made to obtain funds for reprinting several back volumes of the Proceedings which are now out of print. In reply to the notice in the circular relating to the Cincinnati meeting, only a single subscription was received and that was from a member in Virginia, who kindly sent five dollars as "his mite" for the purpose stated. At the opening of the Cincinnati Meeting, a lady member generously placed in my hands $100 for the same purpose, and in General Session on Friday when the attention of members was again called to the importance of obtaining further contributions to the fund, $110 was received in small sums from those present. At that time Gen. Wm. Lilly informed me that he hoped to add his contribution, and he has recently made the generous gift of $1000 to aid in reprinting the volumes. In accordance with the provisions of the constitution Gen. Lilly's name has been placed on the list of patrons of the Association. One of the back volumes will be reprinted during the present year, and it is hoped that additional funds will soon be secured for reprinting one or two others. A list of subscribers to this fund will be given in the Montreal volume.

Since the report contained in the Boston volume notices of the decease of 33 members have been received; of these the names of 17 were announced at the Cincinnati meeting. Included in the number of deceased members are two past presidents, and four original members of the Association. The names of 64 members and fellows have been stricken from the list either from resignation or in comformity with the rule requiring that all who are in arrears for two years shall be omitted from the list.

During the same period the names of 3 old members and fellows have been restored to the list by the payment of arrearages, and at the Cincinnati meeting 404 new members were elected, of which number 319 have paid their admission fee and first assessment and their names have been entered on the list. Seventy-one members were elected fellows at the Cincinnati meeting. Of these 48 have accepted and their names have been transferred to the list of fellows. Three members and fellows have become life members. Prof. William B. Rogers was made first Honorary Fellow of the Association by the joint nomination of Sections A and B and the unanimous vote of the Association.

For a statement of the receipts and expenditures for the financial year terminating just prior to the Cincinnati meeting, and covering the Boston meeting and the publication of the Boston volume of Proceedings, reference is made to the cash account on the following pages.

Of the 182 papers entered on the list for presentation to the sections, one was afterwards referred to the next meeting, two were given as evening lectures, and the rest were read either in full or by abstract in the several sections and subsections. Of the 181 that came to the Standing Committee, for decision as to printing, 118 were accepted for printing either in full or by abstract and 63 by title. Of those accepted, 83 were received from their authors and appear in the present volume. The volume also contains the reports of two committees and the addresses of the Chairmen of the Subsections of Anthropology and Entomology.

The Society for the Promotion of Agricultural Science, the members of which are with few exceptions also members of the Association, held their annual meeting in Cincinnati on the day preceding the meeting of the

Association. Their meeting was well attended and the several papers read were important contributions to science. The officers of the society have expressed their appreciation of the courtesies extended by the Association and the Local Committee in Cincinnati. As the objects of this society are of the highest character in the application of scientific methods to the problems of Agriculture, and as all its members are men of attainments and scientific standing, the holding of its meetings in connection with those of the Association can but prove mutually beneficial.

The meeting of the Association closed with a general session on Tuesday evening. On Wednesday, by invitation, a large party of members and their friends, under the guidance of members of the Local Committee, started on a special train over the Cincinnati Southern Railroad for an excursion to Chattanooga and Lookout Mountain. Special arrangements were made by which the party were able to examine the famous "High Bridge" over the Kentucky river, the construction of which was a marvel of engineering skill. The beautiful scenery along the line of the road through the blue grass region of Kentucky, and the trip to the historic Lookout Mountain were enjoyed by all in the party, while the blast furnace and the extensive works of the iron and tannery companies in Chattanooga offered special attraction to many members. Most of the excursionists returned to Cincinnati Friday night, but by the courtesy of the managers of the railroad a number extended their visit several days.

At the same time that this excursion started for Chattanooga, another, comprised of about 75 members, left for the Mammoth Cave, the Cincinnati and Louisville Railroad company generously giving free passes over their road, and special arrangements were made to convey the party from Cave City to the cave which was reached late in the afternoon. At the Cave Hotel the party were kindly welcomed by the superintendent, Mr. Francis Klett, who did all in his power to make the visit of several days' duration agreeable and instructive, extending to the party many opportunities for the examination of various portions of the cave not often seen by visitors. Several of the members did not return to Cincinnati from this excursion until the following Monday, and a number made three or four visits to the cave. On one of the trips a small grotto which had recently been included in one of the routes was with due formalities named in honor of an officer of the Association.

For a reference to the short excursions which took place during the meeting, and the many kind attentions and hospitalities extended to the members by the citizens of Cincinnati and of Madisonville, I must refer to the report of the General Secretary and to the various resolutions of thanks which were passed at the closing session.

F. W. PUTNAM, *Permanent Secretary.*

APRIL 26, 1882.

F. W. PUTNAM, PERMANENT SECRETARY,

Dr. THE AMERICAN ASSOCIATION FOR

1880-1.		
To Balance from last account		$448 24
Assessments previous to 29th Meeting	$648 00	
" Boston, " " . . .	2,694 00	
" Cincinnati, 30th "	597 00	
" 1882, 31st "	3 00	
	———	3,942 00
Entrance fees Saratoga Meeting	5 00	
" " Boston "	1,975 00	
" " Cincinnati "	140 00	
	———	2,120 00
Publications and Binding	336 05	
Fellowship fees	78 00	
Life Membership commutations	250 00	
	———	664 05
General Receipts:—		
Extra copies of Addresses	22 74	
Postage and express returned	3 13	
Sale of old paper	3 58	
	———	29 45
Illustrations Boston Volume	9 00	
Advertisements on cover in part	30 00	
Local Committee Boston, for Illustrations . .	78 32	
	———	117 32
Subscription towards reprinting volumes		5 00
Balance due Permanent Secretary		773 03
		$8,099 09

SALEM, MASS., AUGUST 3, 1881.

I have examined the above account, and certify that

IN ACCOUNT WITH
THE ADVANCEMENT OF SCIENCE. Cr.

1880-1.

By 2,500 copies Boston Vol. Proceedings:—		
Composition, Stereotyping, and boxes for plates	$1,887 86	
Illustrations, drawing and engraving	96 28	
Paper and press-work	1,986 75	
Covers, comp., paper and press-work	50 00	
Binding 2,365 copies in paper—2 parts	567 60	
Binding 25 in cloth	12 50	
Binding 10 in ½ Turkey	10 00	
25 cloth covers	5 00	
Wrapping 2,265 copies for distribution	25 00	
Postage, distribution of Vol. in part	300 00	
Extra copies, Addresses and Com. Reports	79 15	
		$5,020 14
1,000 Constitutions, List of Members, etc.	85 00	
Expenses Com. on Forestry	2 30	
" Anthropological Section	27 00	
General expenses Boston Meeting	234 97	
		349 27
Expenses on Saratoga Volume:—		
Illustrations	34 75	
Postage, express and distribution of Vol.	133 82	
		168 57
Volumes bought and binding	74 95	
15 boxes for storage of back volumes	19 05	
		94 00
Printing Blanks, circulars, tickets, labels, etc.	145 75	
Box for Assessment Receipts	3 75	
Postage, stamped envelopes, and Postal Cards	260 48	
Paper and envelopes	9 90	
Post Office box to July 1, 1881	4 00	
Subscription to Postal Guide	1 50	
Expressage	43 35	
Telegrams	95	
Office rent to July 1, 1881	100 00	
Janitor to August 1, 1881	45 00	
Fuel	29 00	
Minor office expenses	11 73	
Extra clerk hire	7 15	
		662 56
Expenses on account Cincinnati Meeting	89 41	
500 copies Constitution, List of Members, etc.	65 14	
		154 55
Salary of Assistant Secretary	400 00	
Salary of Permanent Secretary	1,000 00	
		1,400 00
Life Membership Fund		250 00
		$8,099 09

the same is correctly cast and properly vouched.

HENRY WHEATLAND, *Auditor*.

CINCINNATI MUSIC HALL AND EXPOSITION BUILDINGS.

THE

SCIENTIFIC, LITERARY, SOCIAL, ART

AND

EDUCATIONAL INSTITUTIONS AND COLLECTIONS

OF

CINCINNATI AND VICINITY.[1]

THE CINCINNATI SOCIETY OF NATURAL HISTORY takes pleasure in laying before the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, the following brief account of some of the institutions and collections which have helped to foster scientific tastes among us.

R. B. WARDER,
F. W. LANGDON, } Committee.
G. W. HARPER,

THE CINCINNATI SOCIETY OF NATURAL HISTORY.

This body was organized in January, 1870, with twenty-five members, and was incorporated in the following June. For seven years the young society had to depend upon the membership dues to meet the current expenses, but in this time of need, the Trustees of the Cincinnati College liberally provided rooms for the meetings and collections, rent free. At the end of the first year the Society was in debt to the amount of about five dollars; but ever since that time it has been free from incumbrances of every kind.

As the legitimate successor of the Western Academy of Natural Sciences, on September 5, 1871, the Society received the entire property of the old Academy, consisting of about three hundred and fifty dollars in money, a library of two hundred and sixty-five volumes, and a large collection of specimens. Soon after, the former officers of the Academy were elected life members of the new Society.

Dr. John A. Warder was the President during the first five years; and the continued life of the Society at that time was largely due to his efforts to infuse an interest into all the meetings.

[1] Distributed to members of the Association with the programme for the first day of the meeting.

Large donations of specimens were received at various times from Mr. Robert Buchanan, Lieutenant R. L. Browning, Dr. W. H. Mussey, the Cincinnati Zoölogical Society, Mr. John Robinson, and the Ohio Mechanics' Institute. All of these have since been incorporated in the general collections.

In July, 1877, a bequest of fifty thousand dollars, left by a member, Mr. Charles Bodman, was received by the Society. A portion of this was used in the purchase of the building, No. 108 Broadway, now occupied by the Society, and the remainder is kept as a permanent fund for building purposes. Since the occupancy of the present building, in November, 1877, the Society has been in a prosperous condition, and constant additions are being made to its membership and collections.

The paleontological collection is arranged according to zoölogical affinities primarily, and secondarily according to formations and groups. It is in two large cases modelled after those in the Smithsonian Institution, and comprises nearly two thousand species. They are chiefly from Ohio, Indiana, Kentucky and New York. Among them is a fine series of Crinoids from the Crawfordsville, Indiana, beds, and many bones and teeth of the Mammoth and Mastodon from Big Bone Lick, Kentucky. A fine pair of fossil horn-cores of the *Bison latifrons*, Leidy, found in Ohio, may also be mentioned in this connection.

The minerals are well represented in some respects, embracing about four thousand specimens.

The marine shells number about fifteen hundred species; among them are some fine specimens of the Paper Nautilus.

In archæology the principal attraction is a very full collection of prehistoric relics from the Madisonville ancient cemetery.

In ornithology the collection contains two fine large African ostriches, one specimen of the Rhea, or South American ostrich, a cassowary from New Zealand, and numerous skins and mounted specimens of the commoner local species.

In mammalogy there is a fair general collection of mounted specimens and osteological preparations, including the skin and skeleton of *Ornithorhynchus paradoxus*, and a fine example of the substance known as adipocere, which retains the shape of the body of the animal (a hog) from which it originated.

A good collection of botanical specimens occupies one of the rooms.

The officers of the Society are as follows: Dr. R. M. BYRNES, President; Dr. J. H. HUNT, First Vice President; Prof. ORMOND STONE, Second Vice President; Dr. F. W. LANGDON, Secretary; S. E. WRIGHT, Esq., Treasurer.

Members at large of Executive Board. Prof. G. W. Harper, Dr. H. H. Hill, Mr. C. F. Low, Prof. J. Mickelborough.

The above nine officers constitute the Executive Board for the government of the financial and business affairs of the Society:

Librarian, S. A. Miller, Esq.; *Trustees*, R. B. Moore, Esq., Julius Dexter, Esq.; S. E. Wright, Esq.

Curators of Departments. Mineralogy—Prof. J. W. Hall, jr. Paleontology—Prof. J. Mickelborough. Archæology and Ethnology—Dr. H. H. Hill. Botany—Dr. O. D. Norton. Conchology—Mr. E. M. Cooper. Entomology—Mr. Harry J. Hunt. Ichthyology—Dr. D. S. Young. Herpetology—Mr. A. E. Heighway. Ornithology and Mammalogy—Mr. J. W. Shorten. Comparative Anatomy—Dr. A. J. Howe.

The membership now numbers about one hundred and fifty.

Mr. Joseph F. James is Custodian of the Museum, which is open to the public daily (except Sunday), without charge, from 8 A. M. to 5 P. M., at 108 Broadway, corner of Arch street.

East End street-cars pass the door.

THE LITERARY AND SCIENTIFIC SOCIETY OF MADISONVILLE.

This Society was organized in the fall of 1878, by a few gentlemen who met by agreement at the residence of S. F. Covington, Esq., in Madisonville. During the following winter the Society instituted a course of popular lectures of a scientific and literary nature, which were well attended by the public of Madisonville and vicinity. The meetings were held at the houses of the various members, until the spring of 1879, when Dr. C. L. Metz invited the Society to meet permanently in his office, which it has since done. In addition to regular winter courses of lectures, and informal excursions of a scientific nature during the summers, the Society has, since April, 1879, conducted the explorations in the ancient cemetery near Madisonville, which have attracted so much attention in the scientific world. Latterly, a portion of the expense of these excavations has been assumed by the Cincinnati Society of Natural History, which, in return, receives a share in the proceeds.

The following gentlemen compose the Society: Hon. JOSEPH COX, President; S. F. COVINGTON, Esq., Vice President; CHARLES F. LOW, Esq., Secretary; E. A. CONKLING, Esq., Treasurer; Dr. CHARLES L. METZ, Superintendent; H. B. Whetsel, Dr. F. W. Langdon, W. C. Rogers, Joseph Cox, jr., J. A. Hosbrook, A. S. Butterfield, jr., Col. P. P. Lane, Rev. G. W. Lasher, D. D., R. O. Collis, A. A. Hawes, A. S. Oliver, D. S. Hosbrook, Wm. West, Capt. W. W. Peabody, Alonzo Burt.

Honorary Members. A. J. Ferris, C. K. Ferris, Dr. R. M. Byrnes, Dr. Gustav Brühl, Charles F. Stites, Dr. A. M. Johnson, Dr. H. H. Hill, L. M. Hosea.

THE ZOOLOGICAL GARDEN.

The ZOÖLOGICAL SOCIETY OF CINCINNATI was organized July 11, 1873. The credit of originating and carrying out this enterprise is largely due to our German fellow-citizens, and especially to Mr. Andrew Erkenbrecher, the first President.

The grounds cover 26.5 hectars (about 65 acres), and have unusual natural advantages; their topography being beautifully diversified, and a large portion of the grounds covered with native forest trees.

The principal buildings, built of hewn limestone, are the Carnivora, Bear Pits, Monkey House, Aviary, and Restaurant.

The present collection includes, of Mammalia, about 300 specimens; Aves, 550 specimens; Reptilia, 50 specimens; total, 900 specimens.

The officers of the Society for 1881 are: S. LESTER TAYLOR, President; OTTO LAIST, Vice President; ALBERT G. ERKENBRECHER, Treasurer; FRANK J. THOMPSON, Secretary and Superintendent.

Directors. J. M. Doherty, George Fisher, George Hafer, B. Roth, P. Andrew, S. H. Frank.

Main street line of horse-cars runs into the Garden. Vine and Elm street horse-cars pass within two hundred yards of the entrance. A branch of the Cincinnati Northern Railway, now being constructed, will pass through a portion of the grounds. Coupon tickets on horse-cars, ten cents each way.

CUVIER CLUB.

In 1871, a few gentlemen met and formed a Society called the "Ohio Society for the Protection of Game and Fish." In 1874, the name was changed to "The Cuvier Club." The objects of the organization are: the protection of game and fish; to secure the proper legislation and enforce the law; to stock depleted streams with desirable food fishes, and to build up a collection illustrative of Ornithology and Ichthyology, for the education, not only of its members, but also of the general public, in these two interesting branches of natural science.

The Club has been very successful and well managed financially. The membership is about five hundred. Many cases of violation of the game and fish laws have been prosecuted by it, and fields and streams stocked with game birds and fishes.

The present quarters proving inadequate, the Club has purchased a lot on Longworth street, east of Race, and is erecting a building thereon.

The officers for 1881 are: Hon. L. A. HARRIS, President; H. C. CULBERTSON, Esq., First Vice President; T. A. LOGAN, Esq., Second Vice President; ALLAN GAZLAY, Esq., Treasurer; J. F. BLACKBURN, Esq., Rec. Secretary; G. W. CARLISLE, Esq., Corr. Secretary; CHARLES DURY, Esq., Custodian.

The present location of the Club is at No. 200 West Fourth street, east of Plum; and, by special resolution, the rooms will be open to members of the A. A. A. S. at any and all times during their stay. A Reception Committee has been appointed for the occasion, consisting of Hon. T. A. O'Conner, John D. Caldwell, Esq., and Charles Dury, Esq.

THE HISTORICAL AND PHILOSOPHICAL SOCIETY OF OHIO.

THE HISTORICAL AND PHILOSOPHICAL SOCIETY OF OHIO was organized at Columbus, Ohio, in 1831, and met there annually for eighteen years. In 1849, it was united with the Cincinnati Historical Society. This union existed until 1861. The Society was scattered during the war, but in 1869 it was reorganized.

The object of the Society is, in general, the collection and preservation of all books and pamphlets bearing upon American history; in particular, the collection of material for the history of Ohio and of Cincinnati.

The Library now contains about seventy-five hundred volumes, and thirty thousand pamphlets.

The officers for 1881 are: Hon. M. F. FORCE, President; S. E. WRIGHT, Esq., First Vice President; Dr. WM. H. MUSSEY, Second Vice President; ROBERT CLARKE, Esq., Corresponding Secretary; JULIUS DEXTER, Esq., Recording Secretary; E. F. BLISS, Esq., Treasurer; Miss E. H. APPLETON, Librarian.

Curators. Dr. Gustav Brühl, C. P. Davis, Esq., John D. Caldwell, Esq., George Graham, Esq. (deceased), H. A. Ratterman, Esq.

The location is in the College Building, Walnut street, between Fourth and Fifth.

Rooms open to visitors on week days from 10 A. M. to 1 P. M.

THE OHIO MECHANICS' INSTITUTE.

This institution was organized in October, 1826, and chartered in the following February, for the diffusion of knowledge in the arts and sciences, and to promote improvements in manufactures and the mechanical arts.

Lectures on chemistry and other subjects were given in the hall of the Cincinnati College, and in the City Council Chamber; but the need of a separate building was soon keenly felt. Through the exertions of Mr. Miles Greenwood and others, funds were secured to purchase a lot, and on the 4th of July, 1848, the corner-stone was laid for the present building on the corner of Sixth and Vine.

Exhibitions of manufactured goods were held almost yearly from 1838 to 1860; and in 1870, with the coöperation of the Cincinnati Chamber of Commerce and the Board of Trade, the First Industrial Exposition was held. The success warranted a continuance of the Industrial Expositions, in which the scientific features have become more and more prominent. The Ninth Exposition will be held in September and October of the present year.

In 1856, the Institute established its School of Design, a chief object of which is to afford an opportunity to artisans for practical training in industrial drawing. Accordingly, the sessions are held in the long winter evenings, and many of the most assiduous students are among those who are engaged in manual labor through the day. Over five thousand pupils have been enrolled; and there is a public exhibition of students' work at the close of each session.

The Institute had collected a library of over 7,000 volumes, chiefly relating to the industrial arts; but these books were transferred to the Cincinnati Public Library. The present reading-room, however, which is open each day and evening, is supplied with scientific and technical periodicals, besides a valuable series of specifications of patents.

The Department of Industrial Improvements was organized in 1878, in order to examine into the merits of alleged new improvements in the industrial arts, and to confer awards to such as prove worthy. In 1880, it was deemed best to take a further step by establishing the "Department of Science and Arts" on a broader basis. A permanent organization was effected in January, 1881, and Major L. M. Hosea was elected Chairman. Sections of Chemistry, of Mechanics and Engineering, and of Electricity were also organized, and have been engaged in their special fields of work. Valuable papers have been read and discussed. Free public lectures have been given monthly on topics of practical and popular interest. The number of earnest workers, and the enthusiasm already shown in this department, give good promise for the future.

CINCINNATI INDUSTRIAL EXPOSITION.

On the 16th of March, 1870, the respective committees of the Chamber of Commerce, Board of Trade, and the Ohio Mechanics' Institute, held a joint meeting, for the purpose of exchanging views in regard to a joint exhibition. At this meeting, the three committees were united into one general committee, to provide for holding the "Cincinnati Industrial Exposition of Manufactures, Products and Arts, in the year 1870," and the following officers were elected.

Charles F. Wilstach, President; James H. Laws, First Vice President; Josiah Kirby, Second Vice President; H. A. V. Post, Treasurer; Abner L. Frazer, Secretary.

Subsequently, on account of his removal to New York, H. A. V. Post resigned his position as treasurer, and C. H. Gould was elected to fill the vacancy; and Joseph Kinsey was elected to fill the vacancy in committee from the Board of Trade, arising also from Mr. Post's change. A complete list of sub-committees was appointed, and the project was now fairly inaugurated. The remainder of the history * * * * presents steady progress.

The Chamber of Commerce, Board of Trade, and Ohio Mechanics' Institute each appropriated one thousand dollars toward the enterprise, and a guarantee fund of twenty-four thousand dollars was secured from citizens; and, as an evidence of the complete financial success of the exhibition, it may be stated that the entire sum was returned to the subscribers after the close of the exposition. (*Extract from Report of Cincinnati Industrial Exposition*, 1870.)

This, the First Cincinnati Industrial Exposition, was held in the building erected for the National Saengerfest, in 1870, on the site of the present Music Hall and Exposition buildings. During the five years following, expositions were held annually in the same buildings. The Seventh and Eighth Expositions were held in 1879 and 1880, in the combined Music Hall and Exposition Buildings, erected through the generosity of Reuben R. Springer and other public spirited citizens; and, in 1881, the Ninth

Exposition will be held in the same quarters, beginning September 7, and continuing one month.

The scientific features of these Exhibitions have, along with the other departments, steadily increased in magnitude and importance; and a special feature of the present one is the preliminary loan Exhibition of scientific apparatus and natural history material, now open to the inspection of members of the American Association for the Advancement of Science.

In addition to the foregoing, the Museums connected with the following institutions possess features of more or less general scientific interest:

CINCINNATI COLLEGE OF MEDICINE AND SURGERY: George street, between John and Smith.

MIAMI MEDICAL COLLEGE: Twelfth street, between Elm and Plum.

OHIO MEDICAL COLLEGE: Sixth street, between Vine and Race

CINCINNATI HOSPITAL: Occupies the square bounded by Twelfth, Ann, Central Avenue, and Plum streets. Entrance on Twelfth street.

THE UNIVERSITY OF CINCINNATI.

The University owes its existence to Mr. CHARLES MCMICKEN, who left a valuable estate in trust to the city of Cincinnati, in 1858, to establish and maintain a boys' college and a girls' college. Other funds have been added to the original bequest, and the plans have been extended so that the University now embraces three departments, as follows:

ACADEMIC DEPARTMENT.—This department was regularly organized in 1874; the present building, near the head of Elm street, on McMicken Avenue, was occupied in 1875.

With a corps of thirteen professors and instructors, many elective studies are provided in the various undergraduate courses, and a very encouraging attendance of post-graduate students is secured. A special feature in the courses of study is the requirement that each student shall elect some one "principal study" in which to pursue a course of three or four years before receiving a degree. Provision is made for "Licensed Instructors, in imitation of the German "Privatdocenten;" and the experiment has proved quite successful.

There is a good supply of engineering instruments, and well-equipped chemical and physical laboratories. The various collections, illustrating Natural History, Geology, Mineralogy and Chemical Technology, are as complete as could be expected in so new an institution.

THE SCHOOL OF DESIGN.—This department of the University, which was opened in January, 1869, is located at present in College Building, Walnut street, above Fourth.

Well-graded courses of instruction are provided in drawing, decorative design, painting, sculpture, and carving. The school is provided with the necessary plaster casts, drawings, paintings, books of reference,

and other apparatus. The special aim is not merely the study of painting and sculpture, but also the improvement of the industrial arts, by affording to the citizens of Cincinnati, and especially to the operative classes, a thorough technical and scientific education in art and design, as applied to manufactures.

Meritorious specimens of the students' work are selected annually for the very attractive public exhibitions.

THE CINCINNATI OBSERVATORY had its origin in a course of astronomical lectures delivered by Prof. O. M. Mitchel, in the spring of 1842, at the hall of the Cincinnati College. A subscription was raised for a telescope and a building, and a site was donated by Mr. Nicholas Longworth. The corner stone was laid on the 9th of November, 1843, by John Quincy Adams, and in the spring of 1845 the telescope of twenty-eight centimeters aperture was mounted on its pier. Professor Mitchel remained in charge until his removal in 1859, to take charge of the Dudley Observatory at Albany. Besides his purely scientific labors, he accomplished a valuable work in rousing public interest in astronomy by lectures, which were marked by great clearness of thought, vividness of imagination, and beauty of diction.

Prof. Cleveland Abbe took charge in 1869, but the smoke from the city, which had grown until it quite surrounded the Observatory, greatly interfered with his labors. His administration is rendered memorable by the series of daily weather reports which he inaugurated, from which afterward sprang the system now employed by the United States Signal Service, and by his efforts looking toward the permanent establishment of the Observatory in a more eligible location. As a result of these efforts an agreement was entered into by which the sale of the old site was permitted, and the city pledged to maintain the Observatory in connection with the University.

The site now occupied, which was donated by Mr. John Kilgour, is, perhaps, more suitable for astronomical purposes than any other which could have been obtained in Hamilton county. The building is of brick, trimmed with freestone, and consists of a central portion surmounted by a revolving dome and flanked by two wings. It was completed in 1874.

In the spring of the following year, Prof. Ormond Stone was elected astronomer, and a new era of activity was then entered upon. The latitude and longitude of the Observatory have been determined. Transit observations are continually made for the regulation of the standard time of Cincinnati. Over 4,000 measures of double stars have been made and nearly 200 new ones discovered. At present the Observatory is engaged in the preparation of a catalogue of all the stars down to the ninth magnitude, situated between 23° and 31° of south declination.

Board of Directors. Alphonso Taft, Chairman, Louis Ballauf, Wm. McMaster, Francis Dowling, Lewis Seasongood. Patrick Mallon, C. D. Robertson, Samuel F. Hunt, John B. Peaslee, Thos. L. Young, C. G

Comegys, Hiram D. Peck, M. Lilienthal, C. D. Fishburn, John S. Woods, W. W. Dawson, John A. Murphy, William Means, Mayor of Cincinnati, *ex officio*.

Instructors, 1881-1882.

Thomas Vickers, Rector and Professor of History, Albion Place, Mount Auburn.

Henry Turner Eddy, C. E., Ph. D., Professor of Mathematics and Civil Engineering, and of Astronomy, West Walnut Hills.

Frank Wigglesworth Clark, S. B., Professor of Chemistry and Physics, Albion Place, Mount Auburn.

Ormond Stone, A. M., Astronomer, Mount Lookout.

Wayland Richardson Benedict, A. M., Professor of Philosophy, 9 Evans Street, Mount Auburn.

James Morgan Hart, LL. D., Professor of Modern Languages and Literature, Southern Avenue, Mount Auburn.

Edward Wyllis Hyde, C. E., Professor of Mathematics and Instructor in Civil Engineering, Lincoln Avenue, West Walnut Hills.

Albert Gallatin Wetherby, A. M., Professor of Natural History, Ridgeway Avenue, Avondale.

William Oliver Sproull, A. M., Ph. D., Professor of the Latin Language and Literature, and of Arabic, Mason Street, Mount Auburn.

Hugo Walter, Instructor in French and German, Auburn Avenue, Mount Auburn.

W. F. Bridge, Temporary Instructor in the Greek Language and Literature, Foster's Crossing.

Herbert Couper Wilson, A. B., Temporary Assistant at the Observatory, Mount Lookout.

Rosalie G. Hollingshead, Licensed Instructor in Elocution, Avondale.

R. B. Warder, A. M., S. B., Licensed Instructor in Chemistry and Physics, North Bend.

Nelson W. Perry, M. E., Licensed Instructor in Metallurgy, Auburn Street, Mount Auburn.

Thomas Satterwhite Noble, Principal of the School of Design. (Absent in Europe on leave.)

William Henry Humphreys, Teacher of Drawing and Design, and Principal *pro tempore*, West Walnut Hills.

Rebecca Russell Whittemore-Gregg, Teacher of Drawing and Perspective, 50 Dayton Street.

Martha Jane Keller, Teacher of Drawing and Perspective, Miamiville, Ohio.

Louis Thomas Rebisso, Teacher of Sculpture, Sycamore Street, Walnut Hills.

Benn Pitman, Teacher of Wood Carving, Hillside, Fulton.

Nettie Wilson, Temporary Teacher of Drawing and Perspective, Mount Harrison.

George Edward Hopkins, Temporary Teacher of Drawing, Cincinnati.

CINCINNATI MUSEUM ASSOCIATION.

This organization owes its existence to Mr. C. W. West, a citizen of Cincinnati, who, on September 7, 1880, subscribed $150,000 toward the erection of a Museum, on condition that other citizens would subscribe a like amount. This condition has since been more than fulfilled, $320,000 having been subscribed to date. The scheme of organization provides for a board of ten trustees, elected for one, two, three, four and five years (two for each term), by the stockholders, and it is further provided that, "no stockholder, subscriber, trustee, director or member shall ever receive any compensation, gain or profit, from the Association for any use of the Museum Building. The present Board of Trustees consists of the following gentlemen:

JOSEPH LONGWORTH, President; JULIUS DEXTER, Secretary; C. W. West, George Hoadly, A. T. Goshorn, M. E. Ingalls, Elliott H. Pendleton, R. H. Galbreath, S. C. Tatem, John Carlisle.

Eden Park has been selected as the site for the Museum, and the building will be erected on the hill overlooking the Park, with the entrance from the South.

THE WOMEN'S ART MUSEUM ASSOCIATION.

The Women's Art Museum Association is an institution established in 1876, for the purpose of arousing the attention of the people of Cincinnati to the advantage of establishing a Museum of fine Arts in that city. That purpose being virtually accomplished, this Museum Association has made over all its properties to the Cincinnati Museum Association, and simply maintains its organization for the sake of more ably aiding the work of the Museum. Miss E. H. Appleton is the Secretary.

PRIVATE COLLECTIONS IN THE NATURAL SCIENCES.

The following is a list of our principal private collectors in Natural History and allied sciences:

ARCHÆOLOGY AND ETHNOLOGY:—Dr. H. H. Hill, corner Fifth and Race streets; Thomas Cleneay, 444 West Sixth street; Robert Brown, Jr., southwest corner Fourth and Plum streets; Dr. R. M. Byrnes, southeast corner Fifth and Race streets; Florien Giaque, Johnston Building; Dr. Gustav Brühl, corner John and Hopkins streets; Dr. W. A. Dun, Cincinnati Hospital; Charles F. Low, southwest corner Fourth and Plum streets; Dr. F. W. Langdon, No. 36 Arcade; Joseph Cox, Jr., Johnston Building; L. M. Hosea, Pike's Opera House; S. C. Heighway, 86 West Seventh street; Hon. M. F. Force, 89 West Eighth street; L. R. Freeman, 274 West Seventh street; James A. Hughes, corner Central Avenue and Fourth street; H. B. Whetsel, Madisonville, Ohio; S. F. Covington. Madisonville, Ohio; E. A. Conkling, Madisonville, Ohio; Hon. Joseph

Cox, Madisonville, Ohio; Dr. Charles L. Metz, Madisonville, Ohio; Mr. R. O. Collis, Madisonville, Ohio; W. C. Rogers, Madisonville, Ohio; A. S. Butterfield, jr., Madisonville, Ohio; Rev. G. W. Lasher, Madisonville, Ohio; A. S. Oliver, Madisonville, Ohio; Wm. West, Madisonville, Ohio; Capt. W. W. Peabody, Madisonville, Ohio; Alonzo Burt, Madisonville, Ohio; Colonel P. P. Lane, Norwood, Ohio; J. A. Hosbrook, Madeira, Ohio; D. S. Hosbrook, Madeira, Ohio; A. J. Ferris, Plainville, Ohio; Charles K. Ferris, Plainville, Ohio; Dr. Alex. M. Johnson, College Hill, Ohio.

MAMMALOGY:—Charles Dury, Avondale, Ohio; Dr. F. W. Langdon, No. 36 Arcade; J. W. Shorten, 191 West Fourth street.

ORNITHOLOGY:—Charles Dury, Avondale, Ohio; Dr. F. W. Langdon, 36 Arcade; J. W. Shorten, 191 West Fourth street; Colonel James W. Abert, Newport, Ky.; L. R. Freeman, 274 West Seventh street; J. Bonsall Porter, Glendale, Ohio; Julius Balke, jr., 124 West Ninth street; Wm. Hubbell Fisher, Wiggins Block, Fifth and Vine streets; Harry J. Hunt, 41 East Third Street; G. Holterhoff, jr., Avondale, Ohio; Dr. R. M. Byrnes, southeast corner Fifth and Race streets; Dr. A. B. Thrasher, 94 West Seventh street; Ezekiel Workum, 28 Main street; Dr. G. M. Allen, 102 Clark street; Edgar R. Quick, Brookville, Franklin County, Ind.; A. W. Butler, Brookville, Franklin county, Ind.

HERPETOLOGY:—Dr. W. A. Dun, Cincinnati Hospital; A. E. Heighway, jr., 86 West Seventh street.

ICHTHYOLOGY:—Dr. D. S. Young, 248 West Seventh street.

CONCHOLOGY:—Dr. R. M. Byrnes, southeast corner Fifth and Race streets; Prof. A. G. Wetherby, Avondale, Ohio; Prof. G. W. Harper, Walnut Hills, City, Charles R. Judge, northwest corner Sixth and Mound streets; E. M. Cooper, 164 Walnut street; George S. Huntington, 245 Brown street; Mrs. M. C. Morehead, Gilbert Avenue, opp. Beecher, Walnut Hills; Dr. J. H. Hunt, 41 East Third street; G. Holterhoff, jr., Avondale, Ohio; Prof. J. Mickleborough, Walnut Hills, City; S. W. Stanage, Walnut Hills, City.

ENTOMOLOGY:—Charles Dury, Avondale, Ohio, native and exotic Lepidoptera and Coleoptera; J. W. Shorten, 191 West Fourth street, Lepidoptera; Dr. F. W. Langdon, 36 Arcade, Native Lepidoptera; C. G. Siewers, 241 Madison street, Newport, Ky., Lepidoptera and Coleoptera; Charles F. Low, Madisonville, Ohio, southwest corner Fourth and Plum streets, City, Native Lepidoptera; V. T. Chambers, Covington, Ky., Lepidoptera (Tineidæ); Prof. A. G. Wetherby, Avondale, Ohio, Lepidoptera; J. M. Crawford, Avondale, Ohio, Coleoptera; Prof. Wm. Colvin, Walnut Hills, City; Captain Wm. Holden, with P. G. Thomson, Arcade Book Store, Arachnida.

ENTOZOA:—Dr. W. H. Taylor, 329 West Seventh street.

BOTANY:—Joseph F. James, 108 Broadway; Dr. C. J. Funck, 42 Liberty street; Thomas W. Spurlock, 20 Mohawk street; Dr. J. H. Hunt,

41 East Third street; C. G. Lloyd, Newport, Ky; Dr. J. A. Warder, North Bend, Ohio; Prof. J. Mickleborough, Walnut Hills, City; Davis L. James, 177 Race street; Paul F. Mohr, 49 Sycamore; Prof. Wm. Colvin, Walnut Hills, City.

PALEONTOLOGY: — S. A. Miller, 8 West Third street; U. P. James, 177 Race street; Dr. R. M. Byrnes, southeast corner Fifth and Race streets; Paul Mohr, 49, 51 and 53 Sycamore street; Prof. A. G. Wetherby, Avondale, O.; C. B. Dyer, Mt. Harrison, City; Prof. J. Mickleborough, Walnut Hills, City; Prof. J. W. Hall, jr., Covington, Ky; E. O. Ulrich, Covington, Ky.; Prof. R. B. Warder, North Bend, Ohio; Dr. D. S. Young, 248 West Seventh street; W. J. Patterson, 253 Everett street; E. H. Vaupel; John M. Nickels, 114 Everett street; Dr. J. H. Hunt, 41 East Third street; S. W. Stanage, Walnut Hills, City; Charles F. Low, corner Fourth and Plum streets; Wm. E. Cook, East Fairmount, City; George S. Huntington, 245 Brown street; Prof. Wm. Colvin, Walnut Hills, City; Dr. H. H. Hill, corner Fifth and Race streets.

MINERALOGY: — Dr. R. M. Byrnes, southeast corner Fifth and Race streets; Dr. J. H. Hunt, 41 East Third street; Prof. E. S. Wayne, 146 Broadway; Prof. J. W. Hall, Jr., Covington, Ky.; Prof. R. B. Warder, North Bend, Ohio; Prof. J. B. Chickering, 253 West Seventh street; Dr. G. M. Allen, 102 Clark street; Prof. Wm. Colvin, Walnut Hills, City; Dr. H. H. Hill, corner Fifth and Race streets.

MICROSCOPY: — Hon. Jacob D. Cox, 103 Broadway; Dr. J. A. Thacker, 121 West Seventh street; Dr. J. H. Hunt, 41 East Third street; Frederick Eckstein, jr., 136 Broadway; Dr. J. C. Mackenzie, 163 West Seventh street; Dr. E. W. Walker, 268 Elm street; Dr. S. M. Hart, northeast corner Seventh and Mound streets; Dr. G. M. Allen, 102 Clark street; Dr. A. B. Thrasher, 94 West Seventh street; Dr. F. Kebler, 137 West Eighth street; Prof. Joseph Eichberg, M. D., Miami Medical College; V. T. Chambers, Covington, Ky.; Dr. Robert Sattler, 64 West Seventh street; Dr. E. E. Sattler, Cincinnati Hospital; Dr. W. A. Dun, Cincinnati Hospital.

THE LITERARY CLUB.

This club was established in 1849. It consists, at present, of about one hundred members, to which number it is limited by its constitution. It is a social club, with the special aim of promoting the literary and mental improvement, as well as entertainment, of its members. It meets every Saturday evening through the months from October to June; and at each meeting some member reads an essay or discourse on a subject selected by him; but this is not compulsory. All matters of general interest, in literature, history, science, political economy, law, etc., become in turn, the subjects of discussion in these papers. Amongst the members of the club are gentlemen eminent for their ability and learning. As social gatherings the meetings are particularly attractive to its members, and their interest is often increased by the visits of distinguished stran-

gers and travelers temporarily in the city. The records of the club, during an existence of more than thirty years, show, amongst nearly five hundred names, those of many conspicuously known to the nation in its legislative, judicial, and executive departments, and in its armies.

Officers for 1880–81. P. MALLON, President; R. F. LEAMAN, Vice President; E. R. DONOHUE, Secretary; T. M. HINKLE, Treasurer; ALEXANDER HILL, Clerk.

Trustees. John A. Woods, R. H. Warder, Joseph Wilby.

Honorary Members. R. B. Hayes, S. E. Wright.

As the meetings of the club are suspended during July, August and September, their handsome rooms on Fourth street are at present closed.

UNIVERSITY CLUB.

THE UNIVERSITY CLUB OF CINCINNATI was organized in November, 1879, by a number of college graduates, to enlarge the acquaintance between college men in the city, and to promote the spirit of sociality between them.

A Club House, No. 122 W. Seventh street, was rented and furnished with parlors, reading, lunch, card and billiard rooms in the following month, and the club entered the first year of its existence with a membership of about one hundred and twenty-five. Most of the prominent newspapers and periodicals are to be found upon the files of the reading-room, and, in addition, a fine nucleus of a reference library. The success of the club, both financially and socially, has been such as to induce the Board of Management to lease the more commodious building, No. 165 W. Seventh street, for a Club House, after the first of next November. According to the constitution: "Any person of good moral character, who has been graduated from, or been connected for two years in good standing with, a college or university, the United States Military or Naval Academy, or a similar academy of any government, shall be eligible as a member."

The initiation fee is twenty-five dollars; the annual dues, a like amount. The present Board of Management consists of the following: President, GEORGE HOADLY; Vice Presidents, A. F. PERRY, M. T. FORCE, W. N. KING; Recording Secretary, RUSSELL HINMAN; Corresponding Secretary, E. R. DONOHUE; Treasurer, ARTHUR STEM; Executive Committee, Walker Hartwell, F. R. Mitchell, John R. Holmes; Committee on Admission, J. T. Stewart, Thos. A. Mack, J. W. Gaff, L. W. Shaffer, Charles Lehmer.

QUEEN CITY CLUB.

This is a social and literary institution, composed of about three hundred leading professional and business men. Its Club House, corner of Seventh and Elm, is one of the most elegant and commodious in the country. It was built and furnished at a cost of about one hundred and seventy thousand dollars, and contains rooms for conversation, chess,

billiards, cards, and other games, besides dining and reading rooms. A reception and dining room is reserved for the wives and families of the members. Each member holds at least one share of stock valued at $250, and pays annual dues of $75, with a credit of $15 as interest on his stock. Five members are elected yearly to serve for three years as a board of management, and this board alone has the right of accepting or rejecting applications for membership. Visitors must be introduced by members. Elm street and Seventh street horse-cars pass the building.

CINCINNATI GYMNASIUM.

In the summer of 1853, a number of active gymnasts associated themselves as a society and proceeded to carry out their design of establishing a Gymnasium. By calling public attention to the matter, they succeeded in effecting their purpose, and rooms were secured in the old Apollo Building, corner Fifth and Walnut, and supplied with all the principal apparatus then used in a well-appointed Gymnasium.

It soon became evident that the increased membership would require a larger and more convenient hall, and, after occupying the Apollo rooms for seven years, the association secured rooms in the "Commercial Building," corner Fourth and Race, which premises, for the same reason, they were, in 1868, compelled to abandon.

They then leased their present quarters, then known as the "St. Lawrence," securing thereby a magnificent Exercising Hall, 120 feet long, 50 feet wide, and 35 feet high, besides additional apartments, which were fitted up as reading rooms, bath rooms, laundry, etc., making the Cincinnati Gymnasium one of the best appointed and most convenient institutions of the kind in the United States.

The present membership numbers 800, and is chiefly composed of professional and business men of the city.

BOARD OF DIRECTORS.

Hon. E. P. BRADSTREET, President; VICTOR ABRAHAM, Esq., Vice President; Hon. L. M. DAYTON, Treasurer; HENRY L. SMITH, Esq., Secretary; Hon. M. F. WILSON, Hon. M. F. FORCE, JAS. S. WAYNE, Esq.; E. W. MURPHY, Superintendent.

The Gymnasium extends a cordial invitation to every member of the A. A. A. S. to visit their institution and make use of the rooms as they feel inclined. Rooms: No. 102 Fourth street, north side, between Vine and Race.

ROOKWOOD POTTERY.

Built and owned by Mrs. MARIA LONGWORTH NICHOLS. Situated at No. 207 Eastern avenue. This is strictly a private enterprise for the encouragement of the art, and has already acquired an enviable reputation for its wares, samples of which may be seen at John A. Mohlenhoff's, No. 46

and 48 West Fifth street. It is proposed to organize a class of students (number limited to 50), who will receive instruction in Painting and Modeling. The Pottery will be open daily, except Sundays, from 2 to 5 P. M., during the stay of the A. A. A. S. Take East End horse-cars.

THE POTTERY CLUB.

Organized in the Spring of 1879. It is an association of ladies of artistic tastes, for the promotion of matters pertaining to the decorative arts. The members are as follows:

Miss M. LOUISE MCLAUGHLIN, President; Miss CLARA C. NEWTON, Secretary; Miss ALICE B. HOLABIRD, Treasurer. Mrs. E. G. Leonard, Mrs. Charles Kebler, Mrs. George Dominick, Mrs. Walter Field, Miss Florence Carlisle, Miss Agnes Pitman, Miss Fannie M. Banks, Mrs. Andrew B. Merriam.

Honorary Members. Mrs. M. V. Keenan, Miss Laura Fry, Miss Elizabeth Nourse.

The Club occupies rooms at the Rookwood Pottery, which is open to visitors on Friday afternoons, between 2 and 5 o'clock.

THE ETCHING CLUB.

This club dates its existence from 1878. It is an association composed chiefly of amateurs, who meet weekly, or semi-monthly, at the Art Rooms in the Music Hall Building. The Club possesses its own press, which is constantly in use by its members. Art matters in general, and etching in particular, are discussed at its meetings. The Club has no formal organization. Its members are as follows:

Dr. D. S. Young, George McLaughlin, Miss M. Louise McLaughlin, Albert Evans, Miss Nettie Wilson, E. K. Foote, Miss Fletcher, Jerry Cady, Miss Laura Fry, Dwight Huntington, J. H. Sharp, A. J. Winslow, Miss M. T. Davis, Herman Ahlers, H. F. Farny, Will Drake, Col. A. L. Anderson, Miss Caroline Lord, Miss Williamson, R. H. Warder, Emery H. Barton, Edward Gaffney, Dr. Edward A. Patton.

In connection with art matters should be mentioned the Wood Carving School of Mr. Henry L. Fry, No. 70 West Fourth street; and the picture galleries of Wm. Wiswell, No. 70 West Fourth street, P. Smith & Co., No. 56 West Fourth street, and A. B. Closson, jr., No. 186 West Fourth street; also the art store of Mr. Emery H. Barton, No. 24 and 26 Arcade.

PRIVATE ART COLLECTORS.

PAINTINGS:—Joseph Longworth, Henry Probasco, George Hoadly, Geo. K. Schoenberger, Reuben R. Springer, Wm. S. Groesbeck, John L. Stettinius, L. B. Harrison, W. W. Scarborough, Nathaniel W. Baker.

ENGRAVINGS:—William Karrman, J. LeBoutillier, S. C. Tatem, Wm. Henry Davis, George McLaughlin.

BRONZES:—Erasmus Gest.

ETCHINGS:—Dr. D. S. Young. (See also Etching Club).

NUMISMATICS:—Thomas Cleneay, 444 West Sixth street. T. B. Disney, N. E. corner Third and Main streets; W. J. Prescott, 98 Barr street; Jas. A. Hughes, corner Central Avenue and Fourth street.

COLLEGE OF MUSIC.

THE COLLEGE OF MUSIC OF CINCINNATI was incorporated in 1878, with a capital stock of fifty thousand dollars, its stockholders being composed of a number of gentlemen distinguished for their public spirit and æsthetic tastes. Its objects, as stated in the act of incorporation, are as follows: "To cultivate a taste for music; and, for that purpose, to organize a school of instruction and practice in all branches of musical education; the establishment of an orchestra; the giving of concerts; the production and publication of musical works, and such other musical enterprises as shall be conducive to the ends above mentioned." The faculty comprises about thirty-five professors, all eminent in their respective specialties. It has enrolled over six hundred pupils, many of whom have already a well-earned reputation for their superior attainments.

Its officers are as follows:

GEORGE WARD NICHOLS, President; A. T. GOSHORN, Vice President; WM. WORTHINGTON, Secretary and Treasurer; JACOB D. COX, I. BURNET RESOR, R. R. SPRINGER, PETER RUDOLF NEFF, Directors.

The College is located in the Music Hall building corner Elm and Fourteenth streets.

CINCINNATI COLLEGE.

CINCINNATI COLLEGE was established in 1819; and a Lancaster school, organized in 1815, was merged into it. About $40,000 has been subscribed for the foundation of a college and the erection of a college-building; but, by reason of bank troubles, much of the subscription was never paid.

The building was burned in 1845, and shortly afterwards rebuilt, largely by aid of the Young Men's Mercantile Library Association, which, in consideration of its aid, holds a perpetual grant of its rooms on the second floor of the building. In 1869, after the building was again damaged by fire, it was remodeled into its present shape. The College holds a very liberal charter, containing a restriction only against the teaching of denominational theology. The government is vested in a board of trustees, elected yearly by the shareholders. The capital is $125,000, in shares of $25 each. The value of the property is about $200,000. The income is about $10,000, and is used chiefly to support the Cincinnati Law School and its library. The building is popularly known as the College Building. The president is Bishop THOMAS A. JAGGER, and the secretary, A. H. McGUFFEY.

THE CINCINNATI HOSPITAL.

THE CINCINNATI HOSPITAL is one of the largest, most convenient, attractive, and best managed hospitals in the country. It consists of eight distinct buildings, each three stories in height, connected by open corridors and through the basement. The buildings and grounds occupy the entire square bounded by Twelfth, Central avenue, Ann and Plum streets. The buildings surround a large court-yard, with an elegant lawn and flower garden, fountain and grotto.

The hospital contains 500 beds; and private rooms are provided for pay patients. It is a city charitable and educational institution, managed by a board of trustees, seven in number. The medical staff consists of fourteen visiting and six resident physicians; the latter receive their positions after a competitive examination, and serve for one year. In the large and well-appointed amphitheater, capable of seating 400 persons, daily clinical lectures are given, from September to March, which are open to all medical students, on payment of five dollars per session. There is also a fine medical library of over 4,000 volumes connected with the hospital, and open to the medical profession and students without charge.

Strangers and friends of pay patients are admitted at all times, and friends of charity patients on Thursdays only — unless by special permit. Col. H. M. Jones is Superintendent. Twelfth street horse-cars pass the entrance, and the John street and Elm street lines pass within two squares.

SCHOOL FOR DEAF MUTES.

This school was established by the Cincinnati Board of Education, in November, 1875, with Mr. R. P. McGregor as Principal. The method of instruction is that of the Sign Language and the Manual Alphabet. The course of study requires about seven years. Forty pupils were enrolled during the year 1880–81. The location is in the Third Intermediate School-house on Franklin street.

THE CINCINNATI NORMAL SCHOOL.

The Normal School was organized in 1868. Its object is the preparation of teachers for the public schools of Cincinnati. Graduates of the High Schools are admitted without examination. The location, in the Eighth District school-house, affords convenient facilities for the practice department.

The instruction is largely practical; the professional work includes Methods of Teaching, School Management, School law, Mental Philosophy, History of Education, and actual teaching and management of classes. This is the only normal school in the United States which possesses a German department. Mr. John Mickelborough is the Principal.

HIGH SCHOOLS.

WOODWARD HIGH SCHOOL, FRANKLIN STREET, BETWEEN SYCAMORE AND BROADWAY.

In 1826, Wm. Woodward, under the advice of his attorney and valued friend, Samuel Lewis, Esq., resolved to set apart a certain portion of his property for the founding of a free High School.

In 1830, a school-house having been erected on the northeast corner of the present lot, the school was formally opened in the fall of 1831. In 1837, it was chartered as a college and high school, and continued under this charter until 1851, when, through the efforts of Samuel Lewis, Nathan Guilford and others, a joint agreement was entered into between the city and the trustees of the Woodward and Hughes funds, by which agreement the funds were combined, and two high schools established, known as the Woodward and Hughes High Schools, to be governed and controlled by a Union Board, consisting of five delegates from the Trustees of the Woodward fund, two from the Hughes, and six elected annually from the Common School Board. This arrangement has continued for thirty years, during which time over six thousand boys and girls have successfully passed the annual examination, and have been enrolled as students of the Woodward High School.

The present value of the Woodward building, lot, library, apparatus, etc., is $140,000. The other property belonging to the school is leased to different parties, and is subject to revaluation every fifteen years. The present value is about $200,000, and the annual income about $10,000.

Mr. Woodward died in 1833, having lived long enough to see the school which he founded in successful operation.

HUGHES HIGH SCHOOL, FIFTH STREET, OPPOSITE MOUND.

In the northern suburbs of Cincinnati, on an adjoining farm to Wm. Woodward, lived his friend Thomas Hughes, who was moved by the example of Mr. Woodward to leave in his will a certain amount of property for a similar purpose.

The plan of Mr. Hughes was different from that of Mr. Woodward. He bequeathed the property to trustees, to be held in trust until the income should be sufficient to erect a suitable building. These trustees leased the property on perpetual ground rent, not subject to revaluation, so that the yearly income is only about $2,000.

By the joint arrangement with the city and the Trustees of the Woodward fund in 1851, the school was formally established under the name of the Hughes High School. The school was the immediate successor of the Central High School, which had occupied a building on Longworth street for several years prior to 1851, which school was under the immediate control of the Common School Board.

In 1853, a new building having been erected on Fifth street, opposite Mound, the school took formal possession. The present enrollment is over six hundred, and the value of the building, lot, library, apparatus, etc. is about $100,000.

DISTRICT OR COMMON SCHOOLS.

For the education of the youth of the city, Cincinnati provides forty-two district or primary, four intermediate, and two high school buildings. Between six and seven hundred teachers are employed, at salaries ranging from $400 to $2,600 per annum. The periods of attendance required are, six years in the district, three in the intermediate, and four in the high schools. After graduation from the high schools, students may enter the University without reëxamination. The schools are governed by a Board of Education, consisting of twelve "members at large" and twenty-five "members," . . which also control the Public Library, the Normal School, and the School for Deaf Mutes. Night schools are held in fifteen districts, three being for colored pupils. The public schools are supported by a tax, which requires about $700,000. About 37,000 pupils are enrolled. Mr. John B. Peaslee is Superintendent; residence, Gibson House.

PUBLIC LIBRARY.

The Public Library of Cincinnati is situated on the west side of Vine street, between Sixth and Seventh, and is one of the best arranged and most flourishing institutions of the kind in the country. The building is fire-proof, and cost, with the ground, $400,000. It contains about 125,000 volumes, and 20,000 pamphlets, a large proportion of which are of a scientific nature, and in the medical department are 5,000 volumes donated by Prof. W. H. Mussey, M. D. The art department contains a copy of the original elephant folio edition of Audubon's Birds of America. About $60,000 is spent annually for the maintenance of the Library, $18,000 of which is expended for books alone. The Library and Reading Rooms are open daily from 8 A. M. to 10 P. M., and are free to all. Mr. Chester W. Merrill is Librarian.

THE YOUNG MEN'S MERCANTILE LIBRARY ASSOCIATION.

This is a well-selected library of about 40,000 volumes and 5,000 pamphlets; in its Reading Room are over 200 papers and periodicals from all parts of the world. The rooms—situated in College Building, on Walnut, above Fourth—are comfortably fitted up and ornamented with statuary, paintings, etc., and are open daily from 8 A. M. to 10 P. M. Strangers admitted. Henry J. Page is President, and John M. Newton, Librarian.

THE CINCINNATI LAW LIBRARY.

Chartered in 1834, and organized in 1846. It contains about 10,000 volumes, and is one of the most conveniently arranged and most complete law libraries in the country. The rooms are in the Court House,

and open to members, introduced strangers, and to the senior class of the Cincinnati Law School.

CINCINNATI SOCIETY OF NATURAL HISTORY.

108 Broadway. A good collection of proceedings of scientific bodies and works on the Natural Sciences.

CINCINNATI HOSPITAL LIBRARY.

A large and fine collection of rare Medical works and periodicals. Twelfth street, between Central Avenue and Plum.

COLLEGE OF PHARMACY.

Southwest corner Fifth and John streets. A good Botanical and Pharmaceutical Library.

PRIVATE LIBRARIES.

Robert Clarke: Bibliography, History of Literature, Science, Scottish History and Poetry. Peter G. Thompson: Ohio History and Bibliography. A. Gunnison: Art. Hon. A. T. Goshorn: Biographical, Historical, and General. This library, consisting of several thousand volumes, with its appropriate furniture, is a testimonial from the citizens of Philadelphia, in recognition of General Goshorn's services as Director General of the International Exhibition of 1876.

Henry Probasco: A collection of ancient and rare works. Rev. Thomas Skinner, D. D.: Theological. E. T. Carson: Masonic and Shakespearean. Hon. J. B. Stallo: Philosophical. Hon. Stanley Matthews: Law, Science, and Theology. George McLaughlin: Historical and Art. Hon. M. F. Force: North American Indians. T. D. Lincoln: Law. C. F. Low: Americana. E. C. Dawes: American Rebellion.

PARKS AND CONSERVATORIES.

EDEN PARK— East end of city. Take Walnut Hills horse-cars, marked "Park Avenue".

BURNET WOODS PARK— Near Clifton. Take Elm street horse-cars.

LINCOLN PARK — Corner Freeman and Hopkins street. Take Seventh street cars.

WASHINGTON PARK— Elm and Twelfth streets. Take Elm street cars.

CITY BUILDING PARK— Corner Eighth and Plum. Take Seventh street cars.

EIGHTH STREET PARK— Eighth street, from Vine to Elm.

SPRING GROVE CEMETERY— North of city. Take Sixth street and avenue horse-cars; or C., H. & D. R. R.

LONGVIEW ASYLUM— North of city. Take C., H, & D. R. R. to Carthage.


WASHINGTON
WALNUT
HILLS
SPRING
GARDEN
Mill Creek
Mill
Creek
28
LINCOLN
PARK
BELLEVUE
Taylors Creek
RIVER
ROAD
LUDLOW
CINCINNATI HAMILTON & DAYTON R.R.
CINCINNATI & INDIANAPOLIS R.R.
OHIO & MISSISSIPPI R.R.

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7. Gibson House.
8. St. James Hotel.
9. St. Nicholas Hotel.
10. Keppler's Hotel.
11. Carlisle House.
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15. Galt House.
16. Hunt's Hotel.
17. Henrie House.
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Zoological Garden, N. E. of Burnet Woods.

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